Navy Personnel Research, Studies, and Technology Department
Navy Personnel Command (NPRST/PERS-1)
Millington, TN, 38055-1000 NPRST-TN-02-1 August 2002

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Millington, TN 38055-1300

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
31-08-2002	Technical Note	

4. TITLE AND SUBTITLE
How Robust is the Theory of Consumer Choice in the Face of Discrete Goods with Multiple Attributes: An Experimental Approach

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Navy Personnel Research,
Studies, and Technology
(PERS-1)
5720 Integrity Drive
Millington, TN 38055-1300

8. PERFORMING ORGANIZATION REPORT NUMBER
NPRST-TN-02-01

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
A - Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The objective of this study is to examine how individuals make choices when faced with discrete multi-attribute goods. Laboratory methods are utilized to obtain controlled experimental data and test specific hypotheses. The main results are that (a) the relative tradeoff between the attributes is a significant treatment variable and (b) the majority of experimental subjects adopt heuristics that approximate the optimal solution to a complex linear programming problem. Further, the subjects rarely choose a fixed payoff option with a known payoff and low decision cost, even when the fixed payoff is 80% of the maximum possible under the decision-making task.

15. SUBJECT TERMS
discrete goods, experimental economics, choice

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED	77	Kay Bailey
					19b. TELEPHONE NUMBER *(include area code)* 901-874-2115 (DSN 882)

Acknowledgement

This research effort was supported by a grant from the Office of Naval Research, In-House Laboratory Independent Research program, which the authors gratefully acknowledge. The laboratory experiments reported herein were conducted at the Mississippi Experimental Research Laboratory (MERLab) at the University of Mississippi. The MERLab has received generous capital equipment support from the Office of Naval Research, Defense University Research and Instrumentation Program N00014-00-1-0387, and Long Range Scientific and Technology Research Program N00014-98-1-0765. All errors are solely those of the authors. Please do not quote or copy without permission

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Introduction

The problem

For the first time in its history, the U.S. Navy has encountered problems meeting recruitment goals. In Fiscal Year (FY) 97 the shortfall was 7,000 new recruits, and in FY98 it was 6,300. While the Navy is expected to just meet its goal of 53,224 new recruits for FY99, the previous years' combined shortfall of 13,300 has very real consequences for the readiness of the force over the next twenty years. Additionally, the Navy has been experiencing retention problems. Overall first-term retention in FY97 was approximately 30 percent, while in FY98 it increased slightly to 32.8 percent. Second-term retention has remained steady at 49.8 percent, however, in light of the recruiting shortfalls in FY97 and FY98 the retention rate is still critically below what will be needed to insure sufficient fleet readiness in the future.

In an effort to address these issues, the Navy has recently instituted pecuniary incentives, which include numerous enlistment and reenlistment incentives. In addition, Navy has taken measures to close the average 13.1 percent wage gap between comparable military and civilian occupations by increasing basic pay 4.8 percent in FY2000.[1] While effective, offering and/or increasing pecuniary incentives can be prohibitively costly, even if offered to a select group of military personnel.

An additional tool

Pecuniary incentives are only part of the overall military compensation package. Compensation is comprised of pecuniary benefits like salary and bonuses, and of non-pecuniary benefits such as dental and health care. A potential cost-effective tool to induce enlistment and increase retention is a flexible benefits package.

Under such a scheme, the employer (Navy) chooses the level of compensation and the employee (a sailor) chooses the mix of salary and benefits in his/her compensation package. Primarily because of institutional constraints, the Navy has typically ignored this option[2] It is possible that under flexible compensation the employee may perceive that the value of his benefits package has increased, giving rise to greater job satisfaction (White, 1983). Greater job satisfaction may increase employee tenure. Additionally, the labor supply pool from which the employer can draw may increase if prospective employees place a greater relative value on a flexible compensation package.

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[1] Navy Times, December 4, 1998, pp. 11.

[2] The existing benefits package provided to military personnel by the Department of Defense (DoD) is a standardized, relatively inflexible benefits package. Currently, the military is prohibited from offering non-standardized packages to specific groups. With an inflexible package, targeting benefits to increase enlistment and retention may not be a strategy favored either by the employer or the employee. Relative to using pecuniary incentives, the employer's relative labor costs are likely to be greater, as the employer must offer all individuals the identical enhanced-benefits package.

While a flexible compensation scheme may decrease the employer's labor cost, it could increase other costs. Offering a large number of benefit combinations would likely impose substantial monitoring and administrative costs on the employer. Further, employees may attribute very little added value beyond the *kth* option (Bucci & Grant, 1995). The employer, therefore, has an incentive to offer just enough options and associated attributes such that the marginal cost of offering an additional option is just equal to its marginal benefit. Under a flexible scheme, the employee can choose from a variety of combinations, as long as the combinations do not exceed the employer-defined value of the total benefit package.

Multiple-attribute discrete goods

From the employee's point of view, an optimal combination is one that (a) is the most preferred by the employee, given the available choices and (b) extracts the total value of the employer-defined package. Obviously, a given employee's optimal combination will depend in part on his/her preferences. It will also depend on the available choices, i.e., the schedule of options provided by the employer.

In general, benefits are offered to the employee in discrete units, i.e., units cannot be subdivided. Also, each discrete unit has multiple attributes. These two factors (discreteness, multiple attributes) complicate the employee's choice[3] and may cause him/her to choose a sub-optimal combination. The discreteness of the benefits may prevent the employee from extracting the total value of the employer-defined compensation package (see below and Appendix A). The complexity of the employee's decision is compounded by the fact that each discrete benefit has multiple attributes. Too many options may push the limits of the employee's computational abilities, and this may also cause or contribute to a sub-optimal choice.

The prevention or elimination of sub-optimal choices is important for policy. Dissatisfaction with the choice is likely to reduce job satisfaction and job tenure. If the objective of the employer is to encourage enlistment and retention while controlling costs, it is critical that the employer offers a sufficient number of discrete benefits and per-benefit attributes without (inadvertently) inducing too much complexity.

Project objective

The objective of this study is to examine how individuals make choices when faced with discrete multi-attribute goods. Laboratory methods are utilized to obtain controlled experimental data and test specific hypotheses. The main results are that (a) the relative tradeoff between the attributes is a significant treatment variable, and (b) the majority of experimental subjects adopt heuristics that approximate the optimal solution to a complex linear programming problem. Further, the subjects rarely choose a fixed payoff option with a known payoff and low decision cost, even when the fixed payoff is 80 percent of the maximum possible under the decision making task.

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[3] These two factors also complicate the employer's decision on what combinations to offer to the employee. In this project, we focus mainly on the employee's decision making task.

Methodology

Individual decision making

Neo-classical economic theory (Binger & Hoffman, 1998; Varian, 1992) argues that individuals engage in a global constrained optimizing process. In particular, consumer choice theory postulates that a consumer will choose that *basket* of goods that maximizes his/her *utility* (economists' term for well-being or satisfaction) subject to a *budget constraint*. The basket may have a very large dimension. The budget constraint stipulates that total expenditures on the basket of goods cannot exceed the consumer's available budget.

According to neo-classical theory, the consumer chooses an optimal basket, or alternatively, makes an optimal choice if the following two conditions are satisfied. First, the *marginal utility* of the last dollar spent on each item in the basket is equal across all items. Second, the consumer spends all his/her income. See Appendix A for a more thorough explanation of neo-classical consumer choice theory. This theory has two important assumptions: (a) the consumer has no computational or cognitive limits and (b) goods are continuous, i.e., they are infinitely divisible.

In contrast, many decision scientists believe that individuals do in fact have computational or cognitive limits, and that these limits affect an individual's choices. They argue that individuals adopt simplifying techniques when faced with complex decisions. Simon (1955) drew a distinction between substantive and procedural rationality. While some decisions may appear to be sub-optimal when viewed through the lens of neo-classical theory, they are actually the result of an efficient application of decision resources. Smith and Walker (1993) focused explicitly on the tradeoff between decision costs and decision rewards in the context of laboratory market experiments. The individual who equates the *marginal decision cost* with the *marginal decision reward* is making an optimal choice, but in some contexts, that choice differs from the optimal choice implied by neo-classical theory.

This difference of opinion is especially critical when the neo-classical continuity assumption does not hold, i.e., where the object of the choice is a discrete good with multiple attributes. As mentioned above, both the discreteness and the multiple-attribute characteristic complicate the individual's decision making task. These two factors may also interact, which adds to the complexity. Thus (some) decision theorists would argue that an individual would take account of this complexity by developing a decision making heuristic, while (most) neo-classical theorists would argue that this added complexity would have little, if any, impact on the individual's ability to make an optimal choice.

There are three strands of research that address decision making in complex settings (von Winterfeldt & Edwards, 1986). The first investigates the individual assignment of values for commodities with multiple attributes. This strand is largely normative, as the researcher constructs a decision aid to facilitate the "correct" decision. The second strand studies whether individuals are capable of making payoff-maximizing decisions in the presence of multiple attributes. The third looks at whether or not individuals are able to

consistently make payoff-maximizing decisions with multidimensional decisions and meeting multiple constraints. The second and third strands are more positive as they assess the ability of individuals from observations of unaided behavior.

Experimental economics

Economics experiments are used extensively to study individual choice (see Camerer, 1995 for a survey). In an economics experiment, human subjects make decisions in a controlled laboratory setting. The decisions map into a reward medium (typically money); different decisions yield different rewards.

The validity of experimental research in economics is founded on the concept of *induced value*. Real people must make real decisions about objects or activities that have real value. Control is the essence of experimental methodology, and it is critical that the experimenter controls or specifies individual values so that values do or do not differ in a specific way. Decision-makers (i.e., subjects) in economics experiments are assumed to be autonomous, own-reward maximizers. The four precepts behind the concept of induced value are *nonsatiation*, *saliency*, *dominance,* and *privacy*. See Appendix B for additional discussion.

Many experiments, like the one reported here, are computerized. Typically, a group of volunteer subjects (often college students) will arrive at a pre-specified location, like a computer laboratory, and are seated in private carrels, so that their decisions and earnings are private. They are then instructed as to the use of the computer program, and how their decisions determine earnings. During the instructions, subjects are encouraged to ask questions. After completion of the instructions, the decision making phase begins. At the end of the experiment, the subjects are paid their cash earnings (or other rewards) and excused.

The major advantages of experimental economics include independent replication of results, researcher control over the environment from which data is collected, and the ability to isolate and test a single theory (Davis & Holt, 1993). Also, this method can be a cost-effective way to obtain data. In some situations, the collection of field data is either impractical or prohibitively expensive. In other situations, the data simply are not available, regardless of cost, technological requirements, etc., or are not observable in a manner consistent with an explicit test of a theory.

However, the experimental methodology is not without its limitations and valid criticisms. Critics contend that the use of student subjects does not capture the complex decision processes of actual, naturally occurring decision-makers. But empirical studies show that in general, there is little difference between the decisions of students and naturally occurring decision-makers.[4] Another criticism is that the simplicity of laboratory experiments does not accurately characterize the complexities of real-world institutions. While this is true, experimental economics is used to test the robustness of basic economic theories. To the extent that basic theories themselves may not be

[4] See Davis and Holt (1993) pg. 17 for a listing of studies that have compared the decision outcomes of students and real-world decision makers.

specifically applicable to the complex, naturally occurring economic situations, this is not a failure of the methodology but it is likely a result of the inadequacy of the theory (Davis & Holt, 1993).

Experimental methods are complimentary to other empirical methods; laboratory data and field data should not be viewed as substitutes. The results from well-designed laboratory experiments can be used to supplement theory and provide additional empirical analysis.

The Model

This research reports an experiment that explores individual decision making over a stylized discrete multi-attribute good. The relationship between this stylized good and a flexible benefits package is discussed below. For simplicity, the individual decision-maker is referred to as the "subject," as human decision-makers participate as the experimental subjects. The subject chooses units of the stylized good, subject to a constraint, and receives a financial reward that varies with choices made.

The cell selection game

A unit of the stylized good is represented as a cell in an $n \times m$ matrix. Thus the subject's choice set consists of $n \times m$ units of the good. The good is discrete in the sense that the subject cannot choose "part" of a cell; the decision to choose a particular cell is an all or none proposition.

Each cell has three attributes: the *cell payoff*, the *cell weight*, and the *cell value*. The cell weight and cell payoff are fixed, i.e., they are the same for each cell in the matrix. The cell value is a numeric value that varies with each cell. Any time a subject selects a cell, his/her reward is:

$$\begin{array}{l}\text{Reward from}\\ \text{selecting cell } i\end{array} = \text{Cell Payoff} + (\text{Cell Weight} \times \text{Cell Value}_i)\,. \tag{1}$$

The subject's reward from selecting k cells is the sum of the rewards from each of the cells that are selected:

$$\begin{array}{l}\text{Reward from}\\ \text{selecting } k \text{ cells}\end{array} = \sum_{i=1}^{k} [\text{Cell Payoff} + (\text{Cell Weight} \times \text{Cell Value}_i)] \tag{2a}$$

$$= k \times \text{Cell Payoff} + [\text{Cell Weight} \times \sum_{i=1}^{k} \text{Cell Value}_i]\,. \tag{2b}$$

Obviously, if there are no constraints on the subject's choices, the total reward will be maximized if all the cells in the matrix are selected, i.e., $k = n \times m$.

Each subject has a *value limit* that constrains his/her choices. The subject can continue to select cells as long as the sum of the cell payoffs from the selected cells does not exceed the value limit. If the subject selects k cells, then this restriction is expressed formally as:

$$\sum_{i=1}^{k} \text{Cell Value}_i \leq \text{Value Limit} \tag{3}$$

For simplicity, the "available budget" will refer to the difference between the value limit and the sum of k cell values that have been selected:

$$\begin{array}{l}\text{Available budget} \\ \text{after selecting } k \text{ cells}\end{array} = \text{Value Limit} - \sum_{i=1}^{k} \text{Cell Value}_i \tag{4}$$

Thus the decision making task facing the profit-maximizing subject is a constrained optimization problem where equation (2a) or (2b) is the objective function and equation (3) is the constraint. In that sense, the task is analogous to optimization in neo-classical consumer theory.[5] But the good is discrete, not continuous, and so neo-classical theory is not directly applicable. In effect, the subject must solve the integer-programming problem commonly called the "knapsack problem" (Greenberg, 1971). While this type of problem may be intuitively simple, the process of identifying the optimal solution can be extraordinarily complex and typically requires a computerized algorithm. In this experiment, the optimal solution to any given decision matrix is computed with the branch-and-bound method.[6] Of course, the subject does not have such an algorithm at his/her disposal.

The fixed payoff option

As an alternative to selecting cells, the subject may choose a *fixed payoff*. That is, instead of "playing the game" where there are rewards for selecting cells, the subject can "opt out" and receive the fixed payoff as the reward. To aid in the decision on whether to earn the reward by selecting cells or to take the fixed payoff, the subject is informed (via the computerized subject interface) as to the maximum amount available to be earned from selecting cells. While the subject is not guaranteed that to earn this maximum amount, sit is a benchmark by which to gauge the decision to play or take the fixed payoff. The motive for including this alternative reward is discussed below. The subject's incentives regarding the fixed payoff vs. selecting cells in this are discussed further below.

Relation to benefits packages

This model is designed as a simplified version of a flexible benefits package. Here is how the model corresponds to (a simplified version of) the naturally occurring world:

1. The $n \times m$ matrix represents the available benefits offered by the employer.

[5] The collection of cells that the subject selects is analogous to the market basket, and the value limit is analogous to the budget constraint

[6] See Garfinkel and Nemhauser (1972) or Parker and Rardin (1988). The branch-and-bound algorithm is part of the computer interface used to conduct this experiment (see Appendix G). The solutions obtained by this algorithm were also checked against an exhaustive search algorithm.

2. Each cell in the matrix represents a component of the package, such as medical, dental, and childcare policies.
3. The cells that the subject selects represent the package chosen by an employee.
4. The cell value represents dollar value of coverage for each policy.
5. The cell weight represents the monetary value that the employee places on each $1 of coverage.
6. The cell payoff represents the value that the employee places on having a particular type of coverage, independent of the amount of coverage.
7. The total reward in equation (2) represents the monetary value that the employee places on the package selected.
8. The value limit represents the total amount of coverage that the employer is willing to offer the employee; it is the employee's benefits "budget."
9. The fixed payment option represents the monetary value the employee places on an alternative non-flexible benefits package

The constraint shown in equation (3) implies that in this simplified world, the employee pays $1 for $1 worth of coverage, i.e., each unit of cell value counts as one unit against the value limit. This might appear "unrealistic" in that there would be no reason to buy insurance in such a world. But note that if the cell weight is greater than one, then the employee is implicitly purchasing coverage at a discount. For example, if the cell weight is 1.2, then the economic cost of buying $1 of insurance is $0.83.[7]

Also, if the subject chooses the fixed payment option, the subjective costs associated with the decision making task are avoided while positive rewards are still received. In this simplified world, that choice is analogous to accepting a fixed benefits package. The employee receives a benefit, but the actions have no effect on the value of the package or its composition

The Experiment

Design overview

The experiment is a four-cell, 2×2 design with the cell payoff and fixed payoff option as the treatment variables. The cell payoff is either 20 or 100. Holding the cell weight constant, the higher the cell payoff the less the relative contribution of the cell value to the reward from selecting a given cell (see equation (2) above). The fixed payoff is either 80 percent or 50 percent of the maximum possible reward from selecting cells. For example, if the fixed payoff percentage is 80 percent and the maximum possible reward from selecting cells is 2450, then the fixed payment option has a reward of 2032.[8] The

[7] The subject receives a reward of 1.2 per unit of cell value. Thus to get a reward of 100 from selecting a cell (ignoring the cell payoff for the moment), the cell value would have be 100 / 1.2 = 83.33.
[8] This example is actually round 1 and 2 of session S1.

lower the fixed payment percentage, the higher the opportunity cost of foregoing the option to select cells.

The experiment is designed to examine (a) how the subject's choice of cells is affected when the reward from selecting a cell is relatively more or less determined by the cell value versus the cell payoff (with the cell weight held constant) and (b) how the subject's decision to select cells versus taking the fixed payoff is affected by the size of the fixed payoff relative to the maximum possible reward from selecting cells. In the context of benefits packages, item (a) corresponds to an employee's choice between just having a particular benefit in the package (a cell's reward is determined primarily by the cell payoff) versus the amount of the coverage (a cell's reward is determined primarily by the cell value). Item (b) corresponds to the choice between a fixed package and a flexible one. Typically, but not always, fixed benefits are less that those under a flexible package. Of course, a flexible package requires that the beneficiary incur subjective costs of identifying the preferred package. Thus if the subjective costs are high, an employee might choose the fixed package with lower total benefit if the difference between benefits is relatively small.

Tables 1 and 2 show the experimental parameters. For simplicity, the four cells of the experimental design are referred to collectively as "sessions" and individually as sessions S1, S2, S3, and S4.[9] Table 1 shows those parameters that are varied across sessions, and Table 2 shows those that are held constant across sessions.

Table 1. Experimental Parameters Varied Across Sessions

	Session			
Parameter	S1	S2	S3	S4
Cell Payoff	20	100	20	100
Fixed Payoff Percentage	80%	80%	50%	50%
Number of Rounds	9	8	10	11
Fixed Deduction (US$)	$17.00	$18.00	$20.00	$27.00

[9] This same terminology is used with the subjects, although the session numbers that the subject enters into the computerized subject interface are 17, 18, 19, and 20, respectively (section IV.D. below describes the computerized interface).

Table 2. Experimental Parameters Constant Across Sessions

Matrix Dimensions	Cell Values Lower Bound	Cell Values Upper Bound	Cell Weight	Value Limit	Revocable Moves?	Seconds per round	Conversion Rate
5 × 5	100	1000	1.2	2000	Yes	240	0.001

Parameters varied across sessions

The four sessions shown in Table 1 correspond to the four cells of the experimental design. Session S1 has a cell payoff of 20 and fixed payoff percentage of 80, S2 has 100 and 80 percent, S3 has 20 and 50 percent, and S4 has 100 and 50 percent. As noted above, the fixed payoff is a percentage of the maximum possible earnings from selecting cells.

Each session is a series of decision making tasks or "rounds" where the given cell payoff/fixed payoff percentage combination applies to each round. During each round, the subject sees a different decision matrix, and has the option of selecting cells for payoff or choosing the fixed payoff. For example, in session S1 the subject views a total of eight different decision matrices, one in each round. In each of those eight rounds, the cell payoff is 20 and the fixed payoff is 80 percent of the maximum possible earnings from selecting cells in the respective decision matrix.

Table 1 shows that each session has a different number of rounds. The number of rounds per session is varied to mitigate the possibility that subjects alter their behavior in anticipation of the end of a session. Previous research has identified "end of experiment" or "end of sequence" effects. One common control is a randomized ending point (see Davis & Holt, 1998). [10]

Each subject completes all four sessions, i.e., each subject completes 8 + 9 + 10 + 11 = 38 rounds. To control for order effects, a subject completes the four sessions in one of four random sequences. Eighty subjects participate in the experiment, and approximately an equal number are assigned to each sequence. Twenty-one subjects receive the sequence S4-S1-S2-S3, twenty receive the sequence S1-S3-S4-S2, nineteen receive the sequence S3-S2-S1-S4, and twenty receive the sequence S2-S4-S3-S1.

Table 1 also shows a "fixed deduction" that varies with each session. At the end of each session, a deduction is subtracted from the subject's earnings. This deduction is explained to the subject as part of the instructions (see below and Appendix C), and the

[10] The computer program is restarted at the beginning of each session, and the experimental instructions inform subjects that they will complete multiple sessions (see section IV.D. below and Appendices C and G). If all sessions have the same number of rounds, subjects might very well anticipate the last round of a session, which could in turn introduce uncontrolled variation.

amount of the deduction is revealed to the subject as each session begins. This deduction is designed to maintain salient incentives between selecting cells and choosing the fixed payoff option.[11] Alternative methods of maintaining these incentives include a variety of combinations of the parameters shown in both Tables 1 and 2. But (in the authors' opinion) such combinations of parameters have prohibitive drawbacks. For example, small cell weights and cell payoffs (values like 0.00001) can be used, but a subject might then interpret equation (2) as essentially zero, irrespective of the cell value. Similarly, large upper and lower bounds for cell values (like numbers in the 1000s) significantly increase the difficulty of making an optimum or near optimum choice, as does a large dimension matrix. Small dimension matrices trivialize the problem (e.g., the optimum choice is a single cell), as does a small range between the upper and lower bounds of cell values, and very small conversion rates are difficult for subjects to internalize, and the corresponding marginal gain from a choice is unacceptably small.[12] These considerations resulted in the parameters and fixed deductions shown in Tables 1 and 2.

Parameters constant across sessions

Table 2 shows the parameters that are identical in each of the four sessions. All decision matrices that the subject sees are 5×5, i.e., they are square matrices with five rows and five columns. This dimensionality is chosen as it has a sufficiently rich optimal solution. Both the combination and location of cells that comprise the optimal solution vary considerably each round. At the same time, the identification of the (near) optimal solution is sufficiently difficult but not excessive. Based on pre-testing, 4×4 or smaller matrices often have trivial or easily identifiable solutions, and 6×6 or larger matrices have excessively burdensome solutions. In both cases, the results are scientifically uninteresting: In the first, the experimental data are not sufficiently diverse, and in the second, the subject has a very strong incentive to opt for the fixed payoff simply to avoid high decision costs. Square matrices are chosen to assist the subject in comparing individual cells.

Each of the 25 cells of a given matrix is populated with a cell value. The lower bound for each cell value is 100 and the upper bound is 1000 (i.e., the cell values range from 100 to 1000). The computerized experimenter interface randomly populates the individual cells (see below and Appendix G). This range is chosen so that the variety of choices is sufficiently rich, with the computational difficulty significant but not overwhelming. That is, the subject can develop a useful but nontrivial heuristic for deciding which cells to select, and the associated mental calculations are manageable.

The cell weight is fixed at 1.2 in all rounds of all four sessions. Thus, according to Tables 1 and 2 and equation (2), the subject's reward from selecting a cell is 20 + ($1.2 \times$ Cell Value) in sessions S1 and S3, and 100 + ($1.2 \times$ Cell Value) in sessions S2 and

[11] Typically, subjects earn \$10–20 for participation in a two-hour session. Without the fixed deduction, a subject in this experiment would earn around \$60 even simply choosing the fixed payoff each round. Even though an additional \$5–10 could be earned by selecting cells, the subject might very well immediately opt for fixed payoff, regardless of the potential reward from selecting cells, as the former has both a substantially lower time cost and substantially lower decision cost than the latter.

[12] Even with the conversion rate used here, an additional \$E1 is worth one-tenth of one U.S. penny. The authors feel that this is the lowest reasonable rate.

S4. If the cell value is 350 (midpoint of the cell value range), then the cell value comprises 95 percent of the reward in S1 and S3, and 81 percent in S2 and S4. If the cell value is 100 (minimum of the cell value range), the respective percentages are 86 and 54, and if the cell value is 600 (maximum of cell value range) then the respective percentages are 97 and 88.

The value limit is also constant across all rounds of all four sessions. In any given round, the subject may continue to select cells as long as the sum of the cell values that have been selected does not exceed 2000. This value is chosen in conjunction with, and for similar reasons as, the matrix size and cell value range.

The computerized experimenter interface gives the experimenter the option whether or not to allow the subject revocable moves (Appendix G). In this experiment, that option is set to "Yes." That is, the subject can select and then "deselect" a cell by clicking the cell a second time, even after selecting other cells; cells can be selected and deselected as many times as the clock allows (see next paragraph). One of the research questions of interest is the degree with which the subject searches prior to making a final decision for the round. Also, the subject has the opportunity to try different heuristics within the course of a round.

The subject is given four minutes (240 seconds) per round to make decisions. Each round, the subject mouse-clicks either an "accept fixed payoff" button to take the fixed payoff, or an "end round" button to indicate that cell selection is complete. If the subject does click one of these two buttons before time expires, the subject's reward for that round is zero.[13] This time limit is based on pre-testing. In the experiment, the 80 subjects collectively completed 3040 rounds. Only 23 (0.8%) had a zero payoff, i.e., ended before subjects clicked one of the two buttons.[14]

The subject's rewards are expressed in "experimental dollars" or E$, which are converted into U.S. dollars or US$ at the rate of E$1 = US$0.001. For example, E$15,210 = US$15.21. The computer interface (see below) automatically converts the subject's experimental rewards into U.S. currency at the end of each session. As described below, the subject records US$ earnings from the screen onto a paper record sheet, and then subtracts the fixed deduction for the given session. This conversion rate is chosen in conjunction with the other parameters, so as to yield an expected payout in the $15–20 (US) range for the subject's participation in a (roughly) two-hour period.

Procedure

The experiment is a computerized web-based application installed at the Mississippi Experimental Research Laboratory (MERLab) on the University of Mississippi campus.

[13] The time remaining in the round is shown on the subject's screen; see Appendix G. Also, the "zero payoff" was reiterated in the instructions that the subject receives; see Appendix C.

[14] The maximum number of times this occurs for any one subject is twice; there are three such instances (subjects 5404, 7407, and 7323). Only one of those three had two zero payoffs in the same session (7407, S3). Other summary data on the zero payoffs: Five of the zero payoffs are in S1, seven in S2, four in S3, and seven in S4. Thus 61 percent (14/23) occur when the cell payoff is 100. Fifty-seven percent (13/23) occur in rounds 1, 2, or 3. By random-order sequence, four zero payoffs occur in the first random sequence, five in the second sequence, six in the third, and eight in the fourth.

This facility is a state-of-the-art computer laboratory with private computer carrels. The computerized application is comprised of an experimenter interface and a subject interface. Both utilize Microsoft Explorer v5.0 and are described in Appendix G. The subject interface includes computerized instructions.

The subjects are recruited from undergraduate business courses at the University of Mississippi. Participation by the subject involved two visits to the laboratory, which are referred to as Part I and Part II. Part I is instructional training that lasts approximately one-and-one-half hours. Part II is the data collection period, and lasts approximately two hours. The subject is paid earnings from both parts upon completion of Part II.[15] Each subject is paid a $6 participation fee, independent of decisions made, for each part.

The training in Part I familiarizes the subject with the computerized interface, record keeping, and the sequence of events (multiple sessions, fixed deductions, etc.). The decisions from Part II are used in the data analysis. Appendix C provides details of the procedure for both Parts I and II, and the parameters and related information for Part I. A summary is provided in this subsection.

Upon arrival, the subject is assigned a subject number, given a printed earnings record, and seated at one of the private carrels. The subject completes computerized instructions that are part of the interface, and then completes two practice rounds with 2×2 matrices. After finishing, the subject raises his/her hand, and is approached by an experimenter. The subject is queried for questions or clarification regarding the decision making task, and, after all questions are answered, is presented with some brief additional printed instructions and a consent form.[16]

Once the subject has read the additional instructions and signed the consent form, he/she again indicates readiness to proceed by raising a hand. An experimenter writes the first session number and corresponding fixed deduction the subject's printed record sheet. While the experimenter watches, the subject restarts the computerized interface and enters the session number and subject number. The subject then proceeds through all rounds of the given session. After completing the session, the subject again raises a hand, receives another session number and fixed deduction, and restarts the program as the experimenter watches. This process continues until all Part I sessions are completed. After the final Part I session, the subject totals the earnings on the record sheet, signs up for Part II (a least one day, and no more than seven days later), and is excused.

Upon returning for Part II, the subject is again seated at a private computer carrel and given the record sheet from Part I. The subject uses the same subject number in Part II as in Part I. As before, the subject completes the computerized instructions and then completes two practice rounds with 2×2 matrices. After finishing, the subject raises a hand, and an experimenter provides a session number and fixed deduction. As an experimenter watches, the subject restarts the computerized interface and enters the session number and subject number. After completing the session, the subject raises a

[15] This payment schedule is explicitly explained to subjects when they are recruited.

[16] The subjects are explicitly recruited for participation in two parts, with each part on a separate day. The consent form explicitly refers to Parts I and II, so consent is not solicited when the subject returns for Part II. However, after reviewing the instructions and before starting the first session of Part II, the subject is reminded that a consent form was signed during the previous visit. See Appendix C.

hand, and receives another session number and fixed deduction. This process continues until all sessions of Part II are completed.

Upon completion of the final session of Part II, the subject is privately paid the cash earnings from both Parts I and II and is excused. In this experiment, cash earnings in Part I average $14.35, with a low of about $4 and a high of about $25. In Part II, the average is $20.67, with a low of about $3 and a high of about $28. (These figures are exclusive of the participation fees.)

Heuristics

Overview

The fact that the subject faces the integer-programming problem described previously is more than a computational curiosity. Given the complexity of the problem, it is extremely unlikely that an untrained decision-maker (like a typical experimental subject) could solve a problem usually reserved for a computerized algorithm. More likely, a subject will develop heuristics or "rules of thumb" to simplify the decision making task. The effectiveness of a particular heuristic can be evaluated relative to a benchmark (i.e., the optimal solution) or relative to other heuristics.

Here, the experimental design varies the cell payoff across sessions while holding the cell weight and value limit constant (see Tables 1 and 2). Three heuristics stand out because of their simplicity. Each of the three have both a "simple" version and a more sophisticated "advanced" version. Below, the simple heuristics are denoted with an "S" subscript, and the advanced heuristics are denoted with an "A" subscript. The payoff to each heuristic is computed using the 38 matrices viewed by the subject. Where appropriate, trial-and-error is used to determine the choices (the choices were made by the authors using a Microsoft Excel spreadsheet). These choices are meant to be representative. In most cases, there are alternative choices that also conform to the given heuristic rule. Appendix D shows the decision matrices from all 38 rounds, and the choices for each heuristic. Before presenting the payoffs, the individual heuristics are discussed.

Individual heuristics

Under the *High Numbers* heuristic, the subject concentrates on cell values in the 700–1000 range. This rule will result in three or fewer cells being selected. To the extent that it involves the fewest computations, this heuristic has the lowest decision cost. The simple and advanced versions of this heuristic are indicated by H_S and H_A, respectively:

1. HS. Select the highest remaining cell value until the value limit prohibits further selection.
2. HA. Select three cells that (nearly) exhaust the value limit, focusing on cell values in the 800–1000 range, but also selecting outside this range.

In all 38 rounds, heuristic H_S results in the selection of two cells, both in the 800–1000 range. This heuristic often leaves a considerable available budget, but not enough to select the highest remaining cell value. Heuristic H_A typically results in the selection of two cells in the 800–1000 range and one in the 100–300 range. As heuristic H_A selects one more cell than heuristic H_S, and often does a much better job of exhausting the value limit, H_A should yield significantly higher average profit than H_S. Thus, one would expect heuristic H_S to be rarely, if ever, used.

Under the *Middle Numbers* heuristic, the subject concentrates on cell values in the 400–699 range. This rule will result in four or five cells being selected. The simple and advanced versions of this heuristic are indicated by M_S and M_A, respectively:

3. MS. Select four cells in the 400–699 range that (nearly) exhaust the value limit.
4. MA. Select five cells that (nearly) exhaust the value limit, focusing on cell values in the 400–699 range, but also selecting outside this range.

Under heuristic M_S, the average cell value will be around 500, which is close to the midpoint (550) of both the entire cell value range (100–1000) and this middle range (400–699). Heuristic M_A selects one more cell than does heuristic M_S. So if both rules approximately equally exhaust the value limit, then M_A should yield a slightly higher profit: E\$10–20 more in S1 and S3, and E\$90–100 more in S2 and S4. (Recall the cell payoff is E\$20 in S1 and S3, and E\$100 in S2 and S4). But M_A almost always results in a wider range of cell values, so it involves a more complex choice and thus a higher decision cost. Thus one might expect the two heuristics to be used equally as often in S1 and S3, where the expected profit difference is relatively small, and M_A to be used more often in S2 and S4.

Under the *Low Numbers* heuristic, the subject concentrates on cell values in the 100–399 range. This strategy will result in six or more cells being selected, and usually seven or more.[17] To the extent that it involves the most computations, this heuristic has the highest decision cost. The simple and advanced versions of this heuristic are indicated by L_S and L_A, respectively:

5. L_S. Select the lowest remaining cell value until the value limit prohibits further selection.
6. L_A. Select six or more cells that (nearly) exhaust the value limit, focusing on cells in the 100–399 range, but also selecting outside this range.

Heuristic L_S often leaves a considerable available budget, but not enough to select the lowest remaining cell value (although the remaining budget is usually considerably less than under heuristic H_S). Heuristic L_A does a better job of exhausting the value limit, and in 34 of the 38 rounds, both heuristics select the same number of cells[18], so L_A should yield higher average profit than L_S. Thus one would expect heuristic L_A to be used more often.

[17] The one exception is round 5 of S4, where the optimal solution is only five cells.

[18] In rounds 2 and 6 of S1, L_S selects 8 cells and L_A selects 7. In round 1 of S3, L_S selects 9 cells and L_A selects 8, and in round 2 of S3, L_S selects 7 cells and L_A selects 6.

Relation to optimal solution

Heuristic L_A is also intriguing because it mimics is a simple algorithm based on equations (2b) and (3). As noted in previously, the subject knows the maximum amount available to be earned from selecting cells. Substituting this maximum possible earnings for "the earnings from selecting k cells" on the right hand side of (2b), treating equation (3) as an equality so that the value limit can be substituted for the sum of the cell payoffs in (2b), and then solving for k yields:

$$k' = \begin{array}{c}\text{Optimal}\\ \text{number of}\\ \text{cells to select}\end{array} = \frac{\text{Max Possible Earnings} - (\text{Cell Weight} \times \text{Value Limit})}{\text{Cell Payoff}} \qquad (5)$$

Thus the subject can identify the optimal number of cells to select (under the assumption that some combination of cell values can exactly meet the value limit).

In all but 3 of the 38 rounds, heuristic L_A selects the same number of cells as the optimal solution.[19] Additionally, the trial-and-error solution identified using heuristic L_A yields the optimal solution in 34 percent (13/38) of the rounds.[20] Even where L_A does not yield the optimal solution, it results in rewards very close to the maximum possible, as shown in Table 3 below.

Relative payoffs

Table 3 summarizes the reward to these six heuristics, as a percentage of the maximum possible (i.e., optimal) reward. The heuristics are divided into "simple" and "advanced" categories. The numbers in Table 3 are computed as follows. For each of the heuristics, the per-round reward is summed over all rounds in the session. This sum is then divided by the sum of the maximum possible per-round earnings in the session. (This maximum is shown in Appendix D). Letting Z_j denote the reward to heuristic Z in round j of a given session, this can be expressed formally as:

$$\text{Reward to Heuristic}\, Z \text{ in Session S}i = \frac{\sum_{j=1}^{\text{Final Round in S}i} \text{Reward to } Z_j}{\sum_{j=1}^{\text{Final Round in S}i} \text{Max Possible Reward}_j}, \; i = 1,\ldots,4 \qquad (6)$$

The four-session average earnings of each heuristic is shown as the column average in Table 3.

The most obvious result from Table 3 is the clear dominance of heuristic L_A. This heuristic yields over 99 percent of the maximum possible earnings in all four sessions. This is not surprising, given the above discussion regarding this heuristic's approximation of the optimal solution. The other two advanced heuristics H_A and M_A also do reasonably

[19] The exceptions are round 2 and round 6 of S, where L_A selects 7 and the optimal number is 8, and round 2 of S3, where L_A selects 6 and the optimal number is 7.

[20] Rounds 5 and 9 of S1, rounds 1, 4, 5, and 8 of S2, rounds 1, 5, and 6 of S3, and rounds 1, 6, 9, and 10 of S4.

well, averaging 91 percent and 95 percent, respectively, but their performance varies across treatments: in S1 and S3, they earn over 95 percent but in S2 and S4 they earn considerable less. This is especially true of heuristic H_A which only earns about 86 percent in S2 and S4.

Table 3. Rewards to Heuristics as a Percentage of the Maximum Possible Reward

Session	Simple Heuristics			Advanced Heuristics		
	High H_S	Middle M_S	Low L_S	High H_A	Middle M_A	Low L_A
S1	90.8%	97.2%	88.8%	96.4%	98.1%	99.7%
S2	80.0%	89.9%	92.8%	86.6%	93.1%	99.9%
S3	90.9%	97.6%	92.1%	96.6%	93.1%	99.9%
S4	79.1%	88.4%	99.8%	85.2%	91.5%	99.8%
Column Average	85.5%	93.3%	93.4%	91.2%	95.3%	99.8%

Note: Calculations based on data shown in Appendix D.

A few other observations are worth mentioning. First, the simple heuristics do fairly well, but not as well as the corresponding advanced heuristic. This is to be expected, as the advanced versions are typically better at exhausting the value limit. Second, among the simple heuristics, M_S earns the most in S1 and S3 when the cell payoff is 20, while L_S does best in S2 and S4 where the cell payoff is 100. This contrasts with the advanced category, where the best heuristic (L_A) is independent of the cell payoff. Finally, the High Number heuristics H_S and H_A are generally the least profitable, even though they have the lowest decision costs.

Results

Summary

Figure 1 summarizes the outcomes over the 3040 rounds completed by the 80 subjects in Part II (data collection) of the experiment. In those rounds where the subjects choose to "play the game" and select cells, earnings are expressed as a percentage of the maximum possible reward for the respective round. This measure is used so that outcomes from different rounds are comparable.[21]

[21] Recall that the maximum possible reward varies across rounds; see Appendix D.

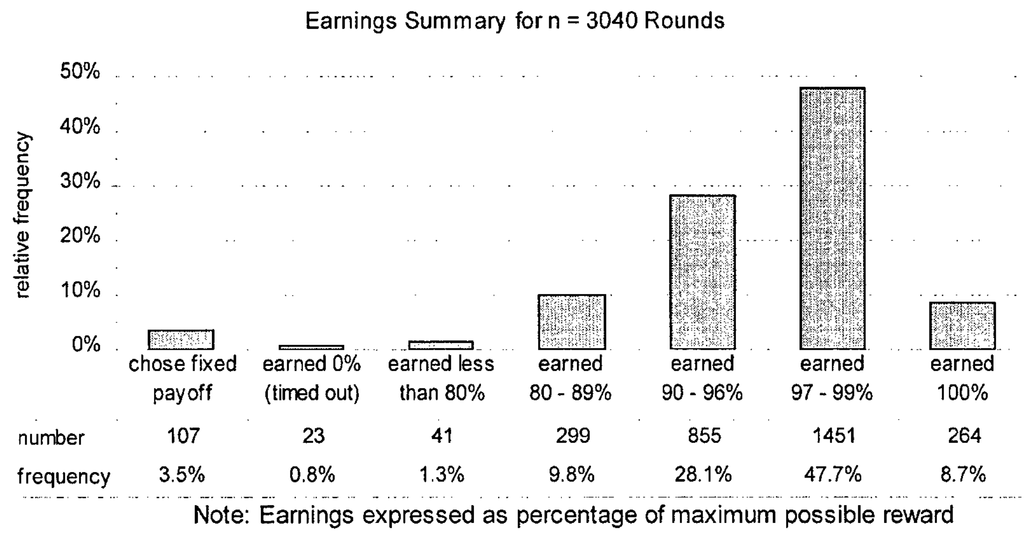

Figure 1. Histogram of Outcomes Across all Four Sessions

The data shown in Figure 1 yield three observations. First, subjects predominantly opt to "play the game" as the means to earning a reward. The fixed payoff option is rarely chosen, occurring in only 3.5 percent (107/3040) of the rounds. Analysis of the data (not shown in Figure 1) reveals that the fixed payoff choice is confined to less than a third of the subjects (24/80). By session, the fixed payoff was chosen 47 times in S1 by 10 different subjects, 46 times in S2 by 18 different subjects, 10 times in S3 by 6 different subjects, and 4 times in S4 by 3 different subjects. Further discussion of the fixed payoff option by session is presented below.

Second, the three-minute time limit per round is not binding. In less than 1 percent (23/3040) of the rounds do subjects "time out," i.e., fail to either choose the fixed payoff option or click the "end round' button when finished selecting cells. Inspection of the data indicates that 20 different subjects "time out" across all four sessions. Three of those subjects time out twice, two of them in two separate sessions, and one of them twice in the same session (S2). By session, time outs occur five times in S1, seven times in S2 (by six different subjects), four times in S3, and seven times in S4.

Third, when subjects choose to play the game, they do quite well. In almost half (47.7%) of the 3040 rounds earnings are in the 97—99 percent range, and in 84.5 percent (= 28.1% + 47.7% + 8.7%) of the rounds earnings are 90 percent or more of the maximum possible. Additionally, inspection of the data (not shown in Figure 1) reveals that low earnings are confined to a subset of subjects. The 339 rounds with earnings less than 90 percent are confined to less than half of the subjects (38/80), and 208 of those rounds are confined to 14 of the 80 subjects. The 41 rounds with earnings below 80 percent are confined to 6 subjects, and 2 subjects account for 32 of those 41 rounds.

Even though subjects consistently earn over 90 percent of the maximum possible, there are differences across treatments. These differences are illustrated in Figure 2, which shows outcomes by session.

Figure 2a. Session S1 (n=720) fixed option = 80%, cell payoff = 20

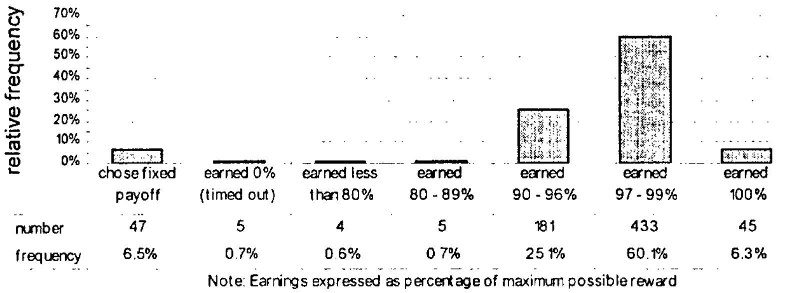

Figure 2b. Session S2 (n=640), fixed option = 80%, cell payoff = 100

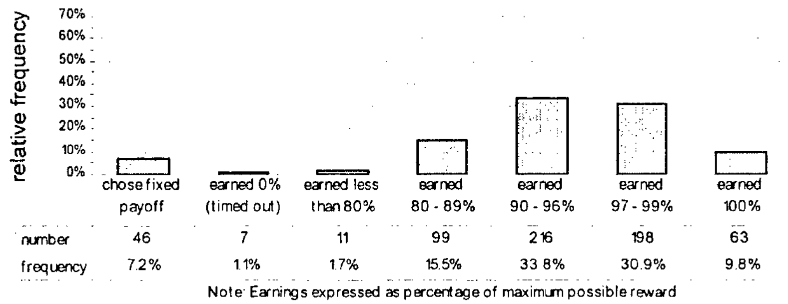

Figure 2c. Session S3 (n=800), fixed option = 50%, cell payoff =20

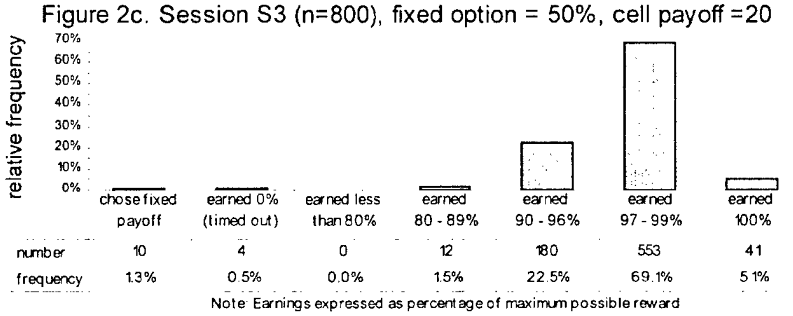

Figure 2d. Session S4 (n=880), fixed option = 50%, cell payoff = 100

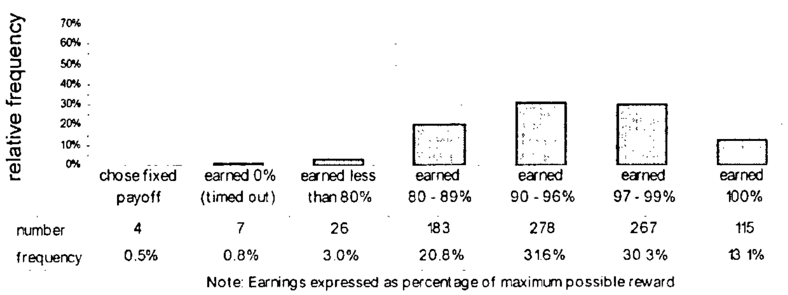

Figure 2. Histograms of Outcomes by Session

First, compare sessions S1 and S3 (Figures 2a and 2c, respectively) with S2 and S4 (Figure 2b and 2d, respectively). In sessions S1 and S3, where the cell payoff is 20, subjects earn 97–99 percent of the maximum possible in over 60 percent of the rounds,

and rarely earn less than 90 percent of the maximum. This contrasts with sessions S2 and S4, where the cell payoff is 100. There, subjects earn in the 97—99 percent range in only about 30 percent of the rounds, and earn less than 90 percent in about 15–20 percent of the rounds. Curiously, subjects are able to earn 100 percent, the maximum possible, more often in S2 and S4 than in S1 and S3 (9.8% and 13.1% vs. 6.3% and 5.1% of the rounds).

But overall, when the cell payoff is 20, earnings tend to be higher and less disperse than when the cell payoff is 100. When cell payoff is relatively low, then the cell value is more important in determining the reward from selecting a particular cell. Perhaps this makes subjects concentrate relatively more on the cell value, and thus more closely approximate the optimal solution. Further discussion on subjects' strategies is presented below.

Fixed effects model

Three fixed effects (or dummy variable) regressions are outlined in Table 4. All three regressions use the same fixed effects model, but use different dependent variables: Earnings Ratio, Cell Ratio, and Search Ratio. Generically, these dependent variables are referred to as Y:

$$\begin{aligned} Y = \beta_0 + \beta_F \text{Fixed} + \beta_T \text{Timeout} + \sum_{i=2}^{4} \beta_{Si} \text{Session}_i \\ + \sum_{j=2}^{11} \beta_{Rj} \text{Round}_j + \sum_{k=2}^{80} \beta_{\text{Sub}k} \text{Subject}_k + \varepsilon \end{aligned} \tag{7}$$

The Earnings Ratio measures the subject's per-round earnings. The question of interest is how well the subject does relative to the optimal solution, so earnings are expressed as a percentage of the maximum possible in the given round of the given session. This normalization controls for the variation in the maximum possible earnings across the 38 total rounds that each subject completes. Thus the Earnings Ratio is one measure of how well the subject does relative to the optimal solution.

The Cell Ratio measures the number of cells in the subject's final choice each round. This variable is a count of the number of cells that the subject has selected as part of the final choice when clicking the "end round" button. Again, the question of interest is how well the subject does relative to the optimal solution, so this variable is expressed as a percentage of the number of cells in the optimal solution for the given round. This normalization also controls for the variation in the optimal number of cells per round across the 38 total rounds that each subject completes. This variable is a second measure of how well the subject does each round, relative to the optimal solution.

The Search Ratio measures the search activity of the subject while controlling for the heuristic used by the subject. The numerator of this ratio is a count of all cells that the subject selects during the course of a round, including those that the subject subsequently deselects, i.e., those that are not part of the subject's final choice. Recall that with the revocable choice option (see Table 2), the subject is able to search out and try different combinations of cells before clicking the "end round" button. The denominator of Search Ratio is the count of the number of cells in the subject's final choice in the round. Recall from previous discussion that the subject's heuristic can be categorized according to the

number of cells that were in the subject's final choice. Thus this measure normalizes search activity so that it is comparable across subjects, as the following example illustrates.

Consider two subjects who both have three cells in their final selection, so both are using a High Numbers heuristic (see previous section). Suppose that the second subject selects and then deselects two additional cells in the process of making a final choice, i.e., a total of five cells are searched while the first subject only searches three. The first subject has a Search Ratio of 3/3 = 1.0, and the second has a ratio of 5/3 = 1.67. The subject who searches more has a higher Search Ratio. Now consider a third subject who has five cells in the final choice, and does not deselect any cells during the round. This subject, who uses a Medium Numbers heuristic, has a Search Ratio of 5/5 = 1.0. Thus according to the this measure of search activity, the first and third subjects search an equal amount, after accounting for the different heuristics they use, and the second subject searches more.

Table 4. Variable in the Fixed Effects Regression Models

Variable	Definition
Dependent Y	
Earnings Ratio	Subject's per-round earnings, as a percent of the maximum possible in the round
Cell Ratio	Number of cells in subject's final per-round choice, as a percent of the number of cells in the round's optimal solution
Search Ratio	Total number of cells subject selects per round (including those not part of subject's final choice), as a ratio of the number of cells in subject's final choice for the round
Fixed Effects	
Fixed	= 1 if subject chooses the fixed payoff option in the round = 0 otherwise
Timeout	= 1 if time expires before subject is finished in the round = 0 otherwise
Session $_i$ $I = 2, \ldots, 4$	= 1 if Y observation from session S*i* = 0 otherwise
Round $_j$ $j = 2, \ldots, 11$	= 1 if Y observation from round R*j* = 0 otherwise
Subject $_k$ $K = 2, \ldots, 80$	= 1 if Y observation from subject Sub*k* = 0 otherwise

Note: The model is shown in equation (7). There are n = 3040 observations of each dependent variable. There are 107 instances where Fixed = 1 and 23 instances where Timeout = 1.

The 94 independent variables are fixed effects dummy variables, as shown in Table 4. The Fixed and Timeout variables control for those rounds where, respectively, the subject chooses the fixed payoff option or time expires before the subject is finished (i.e., before clicking either the "accept fixed payoff" button or the "end round" button). If Fixed = 1, then the Earning Ratio equals the amount of the fixed payoff (divided by the maximum

possible for the round) and both Cell Ratio and Search Ratio equal zero. When Fixed and Timeout = 1, all three dependent variables have a value of zero.

The three Session dummy variables control for individual session effects, and are used to test for the effect of the experimental treatments outlined in Table 1 above. The 10 Round variables control for individual round effects. These variables are used to test for variation over time, such as learning. The 79 Subject $_k$ dummy variables control for a variety of subject-specific effects, including (but not limited to) risk aversion.[22]

Regression results

Table 5 presents the hypothesis tests from the fixed effects regressions. (The entire regression outputs are shown in Appendix E). The models seem to fit the data fairly well, with adjusted R^2s of 0.85, 0.77, and 0.49 for the Earnings Ratio, Cell Ratio, and Search Ratio, respectively. There is strong evidence of a session (or treatment) effect in the Earnings Ratio and the Cell Ratio, as both those p-values are less than 0.01; there is marginal evidence of a session effect in the Search Ratio ($p = .087$). There does not appear to be a round effect in the Earnings Ratio ($p = .260$), but there are significant round effects in both the Cell Ratio and Search Ratio (both p-values < .05). As one might expect, there are strong subject effects in all three ratios. The session and round effects (or lack thereof) are discussed in the remainder of this subsection; the subject effects are discussed in the following subjection

.Table 5. Hypotheses Tests from Fixed Effects Regressions

	Dependent Variable		
Test	Earnings Ratio	Cell Ratio	Search Ratio
Overall Model H_0: $\beta_{S2} = \ldots = \beta_{Sub80} = 0$	$R^2_A = 0.85$ $F = 196.9$ $p < .001$	$R^2_A = 0.77$ $F = 111.2$ $p < .001$	$R^2_A = 0.49$ $F = 29.7$ $p < .001$
Session Effect H_0: $\beta_{S2} = \beta_{S3} = \beta_{S4} = 0$	$F = 174.0$ $p < .001$	$F = 5.07$ $p = .002$	$F = 2.19$ $p = .087$
Round Effect H_0: $\beta_{R2} = \ldots = \beta_{R11} = 0$	$F = 1.24$ $p = .260$	$F = 4.37$ $p < .001$	$F = 2.13$ $p = .020$
Subject Effect H_0: $\beta_{Sub2} = \ldots = \beta_{Sub80} = 0$	$F = 28.1$ $p < .001$	$F = 70.9$ $p < .001$	$F = 13.6$ $p < .001$

Note: n = 3040 for each regression. See Appendix E for further detail.

[22] A dummy variable for session sequence is not included as the order of sessions is varied across subject with one of four random sequences (section IV.B.) in order to control for sequence effects.

Figure 3 plots the estimated values of each of the dependent variables by round. These estimates are obtained using the estimated models shown in Appendix E. In each case, Fixed, Timeout, and Subject_k, $k = 2,\ldots,80$ are all set equal to zero, and Session_i and Round_j are set equal to 1, as appropriate, for the corresponding session and round.

The estimated Earnings Ratio per round is shown in Figure 3a. The nature of the treatment effects is apparent. Sessions S1 and S3 are virtually identical, and S2 and S4 are substantially less, although all four sessions have estimates that are reasonably close to 1.0 (or 100%). This is consistent with the histograms shown in Figure 2. Figure 3a and the significant session effect for the Earnings Ratio (Table 5) are further evidence that a lower cell payoff, and thus a relatively higher importance of cell value, results in higher earnings. Figure 3a also indicates that S4 has lower earnings than S2. In S4, the fixed payoff was 50 percent of the maximum possible, while in S2 it is 80 percent. Recall from Figure 2 that in S2, the fixed payment option is chosen in 7.2 percent of the rounds, while in S4 it is chosen in only chosen in 0.5 percent of the rounds. One interpretation is that the 80 percent fixed payment option provides a cushion in those rounds where the subject does (relatively) poorly, but the 50 percent option does not. However, no such effect is apparent in the comparison of S1 and S3, which have 80 percent and 50 percent fixed payment options, respectively.

Figure 3b shows the estimated Cell Ratio per round. There are two observations to be made. First, S3 and S1 are somewhat dissimilar, which is different from the similarity shown in Figure 3a. In particular, S3 has the highest estimated Cell Ratio, and S1 the lowest. Furthermore, S2 and S4 are very similar, which is also different from Figure 3a, although S2 still has a (slightly) higher estimate than S4. This is somewhat paradoxical: the session that is <u>furthest</u> from the optimal solution in terms of cells (S1 in Figure 3b) is the <u>closest</u> to the optimal solution in terms of earnings (S1 in Figure 3a). While all four sessions have estimates fairly close to 1.0 (or 100%), recall from Table 5 that session effect for the Cell Ratio is significant with a p-value = .002.

Figure 3a. Estimated Earnings Ratio per Round

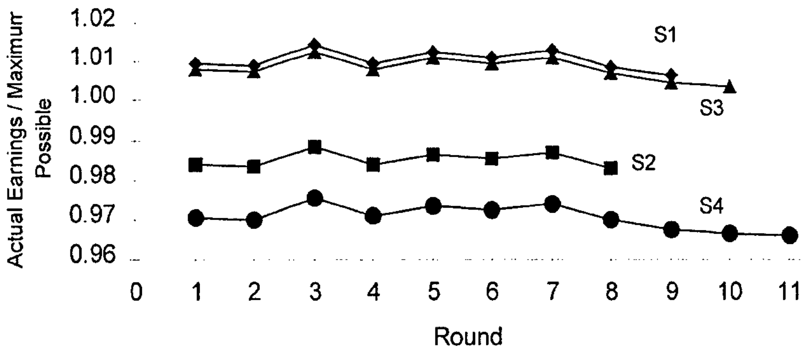

Figure 3b. Estimated Cell Ratio per Round

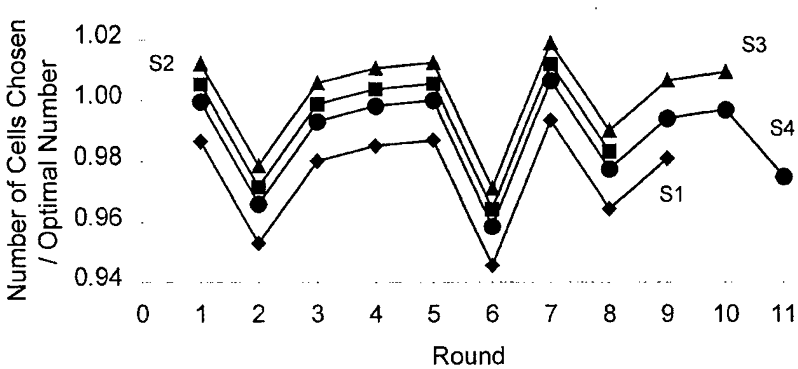

Figure 3c. Search Ratio per Round

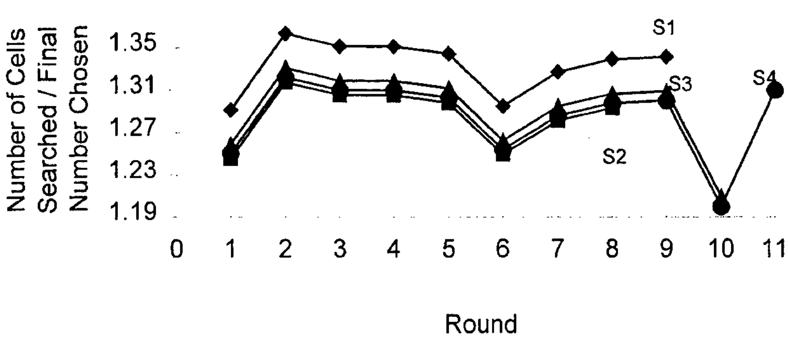

Figure 3. Graph of Estimated Regression Coefficients by Round

The second observation regarding Figure 3b is the unusual decrease in round 6, which accounts (at least in part) for the significant round effect shown in Table 5. While there is variation across all rounds, including decreases in rounds 2 and 8, round 6 is the only one that stands out as exceptional. One possible explanation is a "training effect." Recall that in Part I of the experiment, subjects complete four instructional training sessions, and that each of those sessions lasts five rounds. Perhaps the subjects incorrectly anticipate that round 5 is also the final round in Part II of the experiment. Why subjects systematically choose fewer cells when confronted with an unexpected round, however, remains an open question. However, with the exception of the round 6 decrease, the estimated Cell Ratio is fairly constant across rounds, which indicates the absence of a learning effect. This suggests that the training was otherwise effective in preparing the subject for the data sessions (there is also no evidence of learning in Figure 3a). Whatever the origin or cause of the round 6 decrease, note that it is of no apparent consequence with respect to earnings, as there is no corresponding increase or decrease in the Earnings Ratio shown in Figure 3a.

The estimated Search Ratio is shown in Figure 3c. Recall that Table 5 indicates a marginal session effect for this ratio (p-value = .087). Inspection of Figure 3c suggests that this is due to a difference between S1 and the other three sessions, with more search activity in S1. The estimated search activity is essentially the same in S2, S3, and S4. But there is some search occurring in all sessions, as the average estimated Search Ratio is in the 1.3 range (i.e., greater than 1). The significant round effect (p = .020 in Table 5) is apparently due to the decreases in rounds 6 and 10, rather than a steady increase or decrease across rounds. As with the Cell Ratio, the origin or cause of these decreases remains a mystery.

Observed heuristics

In all three fixed effects regressions, highly significant subject effects are observed (Table 5). To investigate the variation across subjects, each subject's decisions are categorized according to the heuristics discussed previously. Specifically, the number of rounds each session that the subject chose three cells or less, four or five cells, and six or more cells in the final decision are tabulated. Based on the number of times the subject employed the given choice, the subject is then categorized as using a High Numbers, Medium Numbers, or Low Numbers heuristic, respectively, in each of the four sessions. In five separate instances, a subject's decision is labeled Unable to Categorize.[23] Then a designation is assigned to the subject across all four sessions. If the subject receives a High Numbers designation in all four sessions, then he/she is categorized as High Numbers across all four sessions. The same rule is used for the Medium and Low categorizations across all sessions. If the subject is categorized as using different heuristics in different sessions, then categorization as using a Mixed heuristic across session is applied.[24] Appendix F provides details.

[23] In S1, subject 68 chooses the fixed payoff in all 9 rounds and subject 79 chooses the fixed payoff in 8 rounds. In S2, subject 47 chooses the fixed payoff in 7 of the 80 rounds. In S3 subject 50, and in S4 subject 49 appear to employ all three heuristics.

[24] Some assignments were somewhat arbitrary, but these were few in number. For this reason, no formal statistical analysis is performed on the data in Table 6. The interested reader is directed to Appendix F.

Table 6 shows the results of the categorization. There is indeed substantial variation across subjects. One regularity is the frequent use of the Low Numbers heuristic and the infrequent use of the High Numbers heuristic, both when heuristics are identified as "by individual session" or "across session." Approximately half (51%) of the subjects use the Low Numbers heuristic in all four sessions, and over 60 percent use this heuristic in the individual sessions. (Some of the subjects in the "by individual session" Low Numbers row are categorized as Mixed across all four sessions.) By contrast, the corresponding percentages are 5 percent and about 10 percent for the Low Numbers heuristic.

Table 6. *Ex Post* Categorization of Subject Heuristics

Heuristic	Across Sessions	By Individual Session			
		S1	S2	S3	S4
High Numbers (chooses 3 cells or less)	5% (4/80)	10% (8/80)	10% (8/80)	14% (11/80)	9% (7/80)
Medium Numbers (chooses 4 or 5 cells)	16% (13/80)	26% (21/80)	28% (22/80)	25% (20/80)	29% (22/80)
Low Numbers (chooses 6 or more cells)	51% (41/80)	61% (49/80)	61% (49/80)	60% (48/80)	63% (50/80)
Mixed (uses multiple strategies)	28% (22/80)	n/a	n/a	N/a	n/a
Unable to Categorize	n/a	3% (2/80)	1% (1/80)	1% (1/80)	1% (1/80)
Column Total	100% (80/80)	100% (80/80)	100% (80/80)	100% (80/80)	100% (80/80)

Note: Subjects who receive the High, Medium, or Low designation in the Across Sessions column are identified as using that heuristic in each of the four sessions. Of the 23 subjects who use the Mixed strategy, 6 use a combination of Low/Medium, 13 use Medium/High, 2 use Low/High, and 1 uses Low/Medium/High. In the Unable to Categorize row, the subjects who could not be categorized were different in each session, i.e., these are five separate subjects. See text and Appendix F for further detail.

In general, the frequency with which each heuristic is observed corresponds with the profitability of the respective heuristic as shown in above in Table 3: the Low Numbers heuristic is the most profitable, Medium Numbers the second most profitable, and High

Numbers is the least profitable. Most subjects (72%) do not vary their strategy across sessions, but a significant minority (28%) does employ more than one heuristic across sessions and are thus categorized as Mixed. Overall, subjects appear able to employ a heuristic or heuristics that approximate the optimal solution.

Conclusion

This research utilizes the laboratory methods of experimental economics to examine individual decision making over discrete multi-attribute goods. One example of such goods in the naturally occurring world is a flexible compensation or benefits package. Historically, the U.S. Navy has not offered such packages to its personnel. To the extent that such flexible packages increase employee satisfaction, they could potentially be used to induce enlistment and increase retention.

But decision making in such a setting is complex, so increasing decision cost might offset the gains from increased flexibility. This research investigates (in a stylized environment) whether individuals can solve heuristically a challenging discrete multi-attribute goods problem. Analytically, the problem is a linear programming problem that requires sophisticated solution methods. The research also investigates if individuals prefer the decision problem to a "fixed payoff" option with a very low decision cost. One can think of this fixed payoff option as an alternative, defined benefits package.

There are two main results. First, the relative tradeoff between the attributes of the discrete good is a significant treatment variable. The discrete good has two attributes; one that is fixed across choices and one that varies across choices. When a variable attribute has relatively more weight in the overall reward function, subjects earn a higher reward on average. One hypothesis is that with greater weight on the variable attribute, subjects focus on the "essence of the problem" and develop heuristics that closely approximate the optimal solution. Overall, subjects do quite well, as most of the 80 subjects consistently earn 90 percent of the maximum possible reward. Further analysis reveals the majority of experimental subjects adopt heuristics that approximate the optimal solution to the complex linear programming problem.

Second, subjects rarely choose a fixed payoff option with a known payoff and low decision cost, even when the fixed payoff is 80% of the maximum possible under the decision making task. This suggests that the subjects place a high implicit valuation on the flexibility in making choices, and that they appear confident in their ability to exceed the fixed payoff.

Collectively, the results suggest that individuals (at least, financially motivated experimental subjects) can indeed handle difficult decision making tasks like those involving discrete multi-attribute goods. These individuals systematically reveal a preference for the task, as they rarely opt for a fixed payoff option. This indicates that a flexible benefits package may be strongly preferred to a defined benefits package. Future research will reveal the limits of this preference, and the degree to which these results extrapolate to other populations, especially with regard to recruitment and retention of U.S. Navy personnel.

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Appendix A

Consumer Choice Theory

Consumer Choice Theory

Consumer Preferences

The theory of consumer choice postulates that absent any budget constraint, the individual will choose the most preferred consumption bundle or equivalently, the consumer will choose the consumption bundle that yields the highest level of satisfaction or utility. There are four basic assumptions or axioms underlying consumer preferences, they are that preferences are complete, transitive, reflexive, and continuous.

Axiom 1 — Completeness: Given any two consumption bundles, A and B, either A will be preferred to B, B will be preferred to A, or the consumer is indifferent between A and B. (The term 'indifferent' means that the consumer is equally satisfied with either bundle).

Axiom 2 — Transitive: Given any three consumption bundles, A, B, and C; then if A is preferred to B and B is preferred to C, then it must be the case that A is preferred to C.

Axiom 3 — Reflexive: Given any two identical bundles, A and B, the consumer is indifferent between A and B.

Axiom 4 — Continuity: Given three bundles, A, B, and C; if bundle A is preferred to B and if C is sufficiently close to B, then A will be preferred to C.

Intuitively, the first axiom implies that consumers can rank bundles, the second axiom implies that consumer preferences are consistent, the third axiom says a bundle is as good as itself, and the fourth axiom rules out any discontinuities in behavior. If all four axioms hold then individual preferences can be represented by a set of indifference curves, illustrated in Figure A-1.

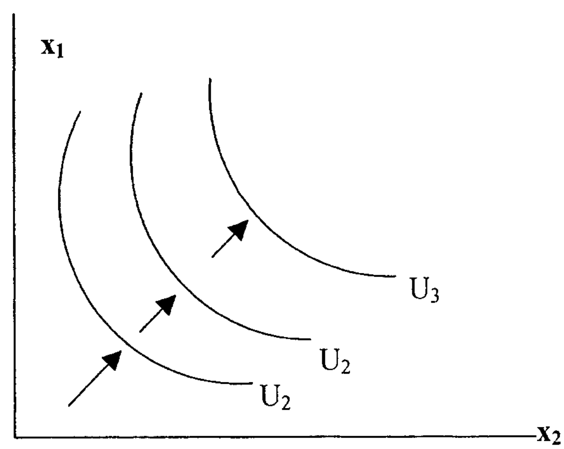


Figure A-1. Map of Indifference Curves

Along an indifference curve there are any number of consumption bundles combinations. All consumption bundles that lie on the same indifference curve yield the same level of the level of satisfaction or utility. Indifference curves that lie further from the origin yield a greater level of satisfaction. Consumption bundles that lie on indifference curve U_3, for example, yield a greater level of satisfaction then consumption bundles that lie on U_2. Similarly, consumption bundles that lie on U_2 yield a greater level of satisfaction than bundles that lie on U_1. Concisely stated, consumers prefer more to less.[1]

While it is understood that consumers are indifferent between consumption bundles that lie on the same indifference curve, the convex shape of indifference curves indicates the consumer's willingness to substitute, say x_1 for x_2, keeping utility constant. This is commonly referred to the as the 'marginal rate of substitution' (MRS). The MRS is determined by taking the absolute value of the slope of the indifference curve. The consumer's willingness to substitute one good for another diminishes as he moves down the indifference curve. In order to induce the individual to give up an additional unit of x_1 the consumer must receive increasingly large amounts of good x_2 and in the extreme no substitution will occur. The diminishing willingness of the consumer to substitute between goods at the margin implies that consumers prefer a balanced consumption bundle relative to bundles that contain strictly one good (Pindyck and Rubinfeld, 1995).

The Basics of Consumer Preference Theory

Consumer theory argues that consumers pick the best or 'preferred' market basket of goods given their income and the price of goods. Economists, when discussing consumer theory must discuss the consumers' budget and preferences as an input into the problem of maximizing utility or satisfaction. A brief tutorial of the assumptions underlying the consumer's budget, preferences, and choice are given below.

The Feasible Set

The budget faced by the consumer constrains the consumer to choose only from market baskets he can afford. In general, the budget is a linear function of prices and income and is defined by the following equation:

(A.1) $$I = p_1x_1 + p_2x_2 + ...+ p_nx_n$$

where I = income

p_i = price of good x_i for $i = 1, 2, ...n$

[1] This assumes all goods are 'good.'

For simplicity, the discussion is restricted to two goods, x_1 and x_2, with prices p_1 and p_2 and all consumption and expenditures occur in the current period.[2] Basic consumer theory, therefore, assumes that the consumer spends all of his income and that there is no intertemporal consumption or savings. The reader will quickly note that this assumption implies that all optimal consumption points lie on the budget line.

A graphical illustration of the budget constraint or feasible set is given in Figure A-2. The budget line cuts the vertical and horizontal axis at the points labeled I/p_1 and I/p_2, respectively. Each one of these points represents an extreme consumption point. For example, the point I/p_1 represents the quantity of good x_1 the consumer could afford if he spent all of his income on x_1. The same applies for the point I/p_2. The consumer can afford any consumption bundle (x_1, x_2) that lies on or below the budget line such as (x_{1a}, x_{2a}) or (x_{1b}, x_{2b}). In contrast, given prices and income, the consumer cannot afford any consumption bundle that lies above the budget constraint, such as (x_{1c}, x_{2c}).

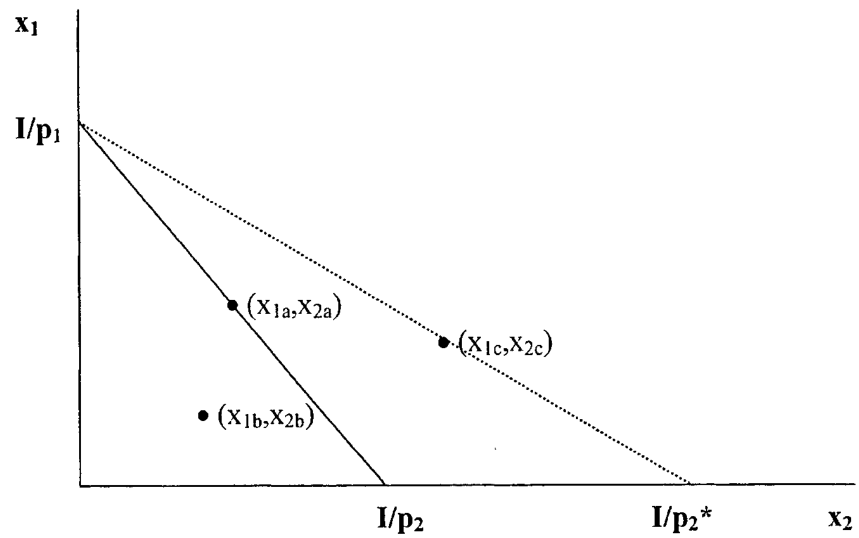


Figure A-2. The Feasible Set

The feasible set is defined by a given set of prices and income. Any change in either prices or income changes the feasible set, that is, the consumption bundles the consumer can afford. To see how changes in prices or income affect the feasible set, rewrite Equation (10) in terms of x_2 to give:

(A.2) $\quad x_1 = I/p_1 - (p_2/p_1)\, x_2$, where the vertical intercept $= I/p_1$ and $-(p_2/p_1) =$ slope

Any change in income is reflected in a change in the value of the intercept and results in a parallel shift of the budget line. Increases in income shift the budget constraint out, increasing the size of the feasible set; while decreases in income contract the feasible set.

[2] It is a common practice to lump goods together and treat them as one good. I will refer the reader to Silberberg, pp.381–384 for a proof of the composite commodity theorem.

Changes in the price of a good(s) will cause the budget line to pivot or rotate. To illustrate, assume a decrease in the price of x_2, holding p_1 fixed. From Equation (11) the reader will note that the slope of the budget line is now relatively smaller. In Figure A-3 the pivot out of the new budget line (I/p_1, I/p_2^*) reflects the decrease in the price x_2. Intuitively, bundles such as (x_{1c}, x_{2c}) which were previously not affordable are now affordable. An opposing argument holds in the case of a price decrease.

Consumer Choice—Utility Maximization

Economic theory postulates that absent any budget constraint rational individuals prefer more to less. The consumer's budget, however, restricts the consumer's choice to consumption bundles he can afford. The consumer, therefore, maximizes his utility subject to the budget constraint. Figure A-3 illustrates the consumer choice problem.

The consumer's budget constraint is given by I/p_1, I/p_2. The consumer's preferences are depicted by indifference curves U_1, U_2, and U_3. All consumption bundles on indifference curve U_3 are not affordable and therefore are not in the feasible set. Consumption bundles such as (x_{1a}, x_{2a}), (x_{1b}, x_{2b}) or (x_{1c}, x_{2c}) lie within the feasible set. The objective of the consumer is to maximize his utility subject to the budget constraint. Even though bundles (x_{1a}, x_{2a}) and (x_{1b}, x_{2b}) are affordable they are not utility maximizing bundles. Bundles (x_{1a}, x_{2a}) and (x_{1b}, x_{2b}) lie on indifference curve U_1; by choosing an alternative combination of goods, such as (x_{1c}, x_{2c}) which lies on U_2, the consumer can obtain a higher level of satisfaction. It is also at this point where the slope of the budget line is just equal to the slope of the indifference curve.

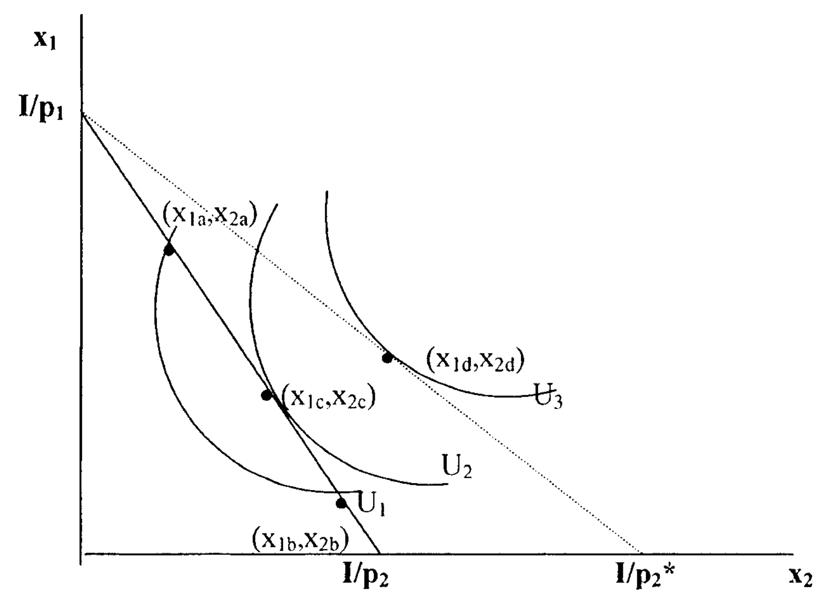


Figure A-3. Consumer Maximization Choice

A critical implication of this result is that the ratio of the prices (marginal cost) is just equal to the marginal utility (marginal benefit) associated with the good. Any other bundle yields a non-optimal solution. If the price ratio of the goods is greater than the ratio of the marginal utilities, such as given by bundle (x_{1b}, x_{2b}), the consumer is better off choosing an alternative market basket of goods such as (x_{1c}, x_{2c}).

It is important to note that any increase in income or decrease in price changes the feasible set, and thus the utility maximizing bundle. For example, a decrease in the price of x_2 pivots the budget line out to I/p_1 , I/p_2*. Whereas, under the original prices bundle (x_{1d},x_{2d}) was not affordable, but has now become affordable.

A Mathematical Approach to the Consumer Choice Problem

The consumer choice problem is to maximize his or her utility subject to a budget constraint. As discussed previously, the optimal solution to the problem is found when the slope of the budget line is just equal to the slope of the indifference curve. Alternatively, utility maximization occurs when the ratio of the price,(p_2/p_1), is equal to the ratio of the marginal rate of substitution. In an effort to provide rigor and clarify the concepts of utility, MRS, and marginal utility; a mathematical approach to the consumer's constrained optimization problem is detailed in this section.

Let an individual's preferences be represented by the following utility function. (A utility function is an ordinal representation of individual preferences. The form of the utility function defines the shape and slope of indifference curves.):

(A.3) $$U = U(x, y)$$

Equation (A.3) says that utility is a function of two goods, x and y. Total differentiating equation (A.3) gives:

(A.4) $$dU = dU_x dx + dU_y dy$$

Noting that dU = 0 and rearranging equation (A.4) gives:[3]

(A.5) $$dy/dx = - U_x/U_y$$

where U_x= marginal utility of x

U_y = marginal utility of y

Multiplying both sides of equation (A.5) by -1 gives:

(A.6) $$- dy/dx = U_x / U_y = MRS$$

[3] Along an indifferent curve utility is constant, therefore dU = 0.

From equation (A.6) we know that the slope of the budget line is(p_x/p_y), utility maximization requires that equation (A.7) hold:

(A.7) $\quad -(p_x/p_y) = - U_x / U_y$

A proof of equation (A.7) is as follows:

(A.8) $\quad$ maximize $U = U(x, y)$ $\quad$ objective function

(A.9) $\quad$ subject to $M = p_x x + p_y y$ $\quad$ the constraint

The Lagrangian equation is as follows:

(A.10) $\quad L = U(x, y) + \lambda(M - p_x x - p_y y)$

Taking the partial derivatives of equation (A.10) with respect to x and y and solving for λ gives:

(A.11) $\quad \lambda = U_x / p_x = U_y / p_y$.

Rewriting equation (A.11)

(A.12) $\quad U_x / U_y = p_x / p_y$.

And by equation (A1.7)

(A.13) $\quad MRS = p_x / p_y$

In general, this result holds regardless of the functional form of the utility function.

<u>A Discrete Choice Model</u>

The standard consumer choice problem assumes that goods are infinitely divisible. This assumption, in part, ensures that there exists an optimal utility maximizing point. There are, however, goods that can only be consumed in discrete units. Examples include clothing, units of education, cars, and compensation packages.

In the case of discrete goods, instead of indifference curves there are indifference points, as illustrated in Figure A-4. Consumption bundle (x_{1a}, x_{2a}) is at least as good as bundle (x_{1c}, x_{2c}). Similarly, bundle (x_{1b}, x_{2b}) is at least as good as bundle (x_{1d}, x_{2d}). Bundle (x_{1a}, x_{2a}) and (x_{1d}, x_{2d}), however, are preferred to bundle (x_{1c}, x_{2c}) as they lie on a higher indifference curve.

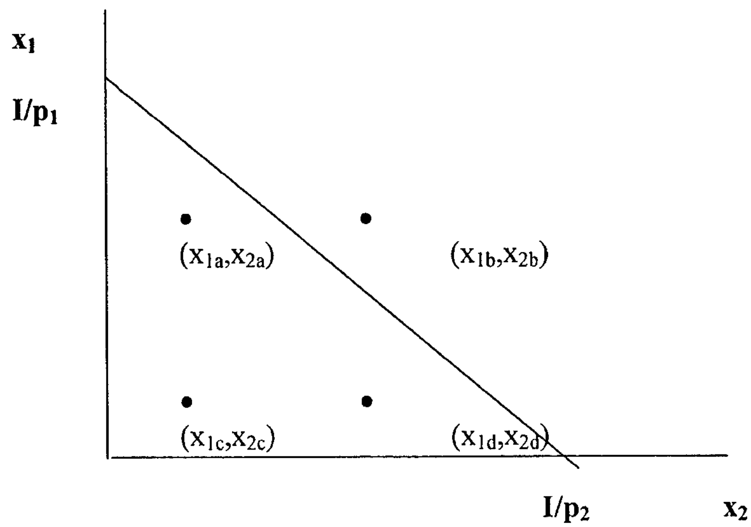


Figure A-4. Discrete Consumer Choice

In general, the results derived previously continue to hold in the case of a discrete good. It is possible, however, that in the presence of discrete goods the consumer cannot maximize his utility. Given the budget constraint I/p_1 I/p_2 the consumer cannot afford bundle (x_{1b}, x_{2b}). The example in Figure A-4 presents no utility maximizing solution. The consumer cannot reach an optimal point given the slope of the budget line and the discrete nature of good x_2. The consumer must, therefore, decide which bundle is the relatively better bundle (x_{1d}, x_{2d}) or (x_{1a}, x_{2a}). The complexity of the consumer's choice is further exacerbated if, for example, goods x_{2d} and x_{2a} consist of numerous attributes.

In this example the nature of the consumer's constrained maximization problem is twofold. The consumer must consider the marginal cost and benefit of not only substituting between the two goods x_1 and x_2, but between the attributes of the goods x_{2a} and x_{2d}. Discrete goods that have multiple attributes increase the complexity of the individual's choice set and may prevent the individual from choosing the 'best' possible bundle; a testable violation of standard consumer choice theory. When the consumer must compare across complex bundles rather than across individual goods, he/she may be unable to consistently perform the pair-wise comparisons required of the complete ordering axiom. Such incompleteness in the preference set may introduce intransitive behavior. Further, the individual may exhibit satiation due to an unwillingness to expend further cognitive resources in decision-making.

References cited in this appendix are included in the references to the main text.

Appendix B
Experimental Economics Protocol

Experimental Economics Protocol

Brief Overview of Experimental Methods in Economics

Empirical research in economics and finance has typically been limited to field studies that use data from the naturally occurring economy, e.g., stock market prices or consumer spending patterns. Over the past three decades laboratory methods have been accepted as an alternative means of generating data and evaluating economic theory. Experimental research has been published in highly reputable academic journals, and experiments are conducted at major universities across the United States. Funding for economics experiments has been provided by a wide variety of agencies, including the National Science Foundation and government agencies like the U.S. Department of Energy and U.S. Department of Defense.

In economics experiments, human subjects make decisions in a controlled environment, and they receive cash rewards based on those decisions. The decisions involve no physical, financial, or psychological risk. The relationship between decision and reward is explained fully to the subjects. Participation is voluntary, and requires no prior financial commitment on the part of an individual. A thorough discussion of the methodology appears below. Here is a summary of the important points regarding participation, decisions, and rewards under the standard protocol:

1. The participants are student volunteers who agree to participate in an experiment where they will make decisions and receive cash earnings based on those decisions.
2. Participants are not subject to physical, financial, or psychological risk. In IRB terminology, the research involves minimal risk.
3. No decision that a subject makes could ever place that person at risk of criminal or civil liability, or damage the subject's financial standing or employability. Furthermore, participants are never identified in published research.
4. Experimental participants are well compensated for their time. How choices are made, and the rewards associated with different decisions, are clearly and completely explained during an instruction period. Each subject is privately paid his/her total cash earnings.
5. Economics experiments do not employ any deception whatsoever.
6. Nothing in the experimental research involves "sensitive" aspects of a participants life, i.e., illegal conduct, substance abuse, sexual conduct, etc. The type decisions that subjects make are laboratory versions of decisions that economic agents make every day in the naturally occurring economy.

Experimental Economics Methodology

The basic experimental economics methodology is to create an artificial, controlled, and monitored environment that is homomorphic to a naturally occurring economic

institution. Subjects are allowed to interact in that institution, making any decisions that they feel are in their best interests. For example, a subject may be a buyer in a market, and lower buying prices would mean greater profit for that subject. The subject would have to decide at which price he/she is willing to buy. At the end of the experimental session, the subjects are paid whatever earnings accrued to them from their decisions. Details of each aspect of the methodology are:

Subjects: Experimental subjects are typically recruited from undergraduate business courses. They are told that (a) an experimental market is being run and the amount of time the market is likely to take, (b) if they volunteer to participate they will be paid a show-up fee (usually $5), and (c) they will have the opportunity to make more money in the market. It is explained that no amount of money is guaranteed, as it depends on the decisions a subject makes, but that most students request to participate again. Occasionally subjects are recruited from other populations such as science and engineering classes, or persons from outside the university who are actively involved in a specific business.

Payoffs: As mentioned above, a show-up fee is paid to each subject. In addition, subjects are paid the amount of money that they earn in the specific market. These payoffs are designed to make the decisions that the subjects must make salient. Average payoffs are in the $5–$8 dollars per hour range, but may range from $0 to over $100, depending on the experimental design. If a subject makes negative profits during an experiment they keep their show-up fee but are paid nothing for participating in the market.

Names: Subjects are asked to identify themselves as they begin the instructions, so that they can be identified when payments are made. Also, upon receipt of their final cash payments, subjects are asked to sign a receipt form, and give an identification number (like social security number) in order to maintain records of cash disbursements. The names are not recorded with the decision data, and no other use is made of the names other than for payment and accounting purposes.

Instruction: Prior to each experiment, subjects go through extensive instructions that explain how the market works, and how they will be able to make money. Typically the instructions contain several examples of the kinds of decisions that subjects will be asked to make. Subjects are allowed to take as long as necessary to complete the instructions, and are encouraged to ask questions throughout the instruction period and during the experiment.

Privacy: All decisions made by the subjects are private, and subjects are not permitted to talk to each other during experiments. (There are rare instances where subjects participate in groups to make decisions. In those instances, no threats or side payments are allowed. The experimenter closely watches the group to ensure that the rules are followed.) Payments at the end of the experiment are made individually and privately.

Deception: Extreme care is taken never to deceive the subjects in any way. It is essential to the development and analysis of theory that each subject feel that if they are told something about the market, then it is absolutely true. This does not mean that everyone is told everything about every market. Just as with naturally occurring markets, there are times when a person has incomplete information. However, they must feel that anything they are told will be true.

Paying Salient Rewards in Economics Experiments

The validity of experimental research in economics is founded on the concept of *induced value*. Real people must make real decisions about objects or activities that have real value. Control is the essence of experimental methodology, and it is critical that the experimenter control or specify individual values so that he/she can state that values do or do not differ in a specific way. Generally speaking, laboratory experiments in economics presume that decision makers are autonomous, own-reward maximizers. The four precepts behind the concept of induced value are nonsatiation, saliency, dominance, and privacy. These precepts are:

Nonsatiation: Given a costless choice between two alternatives, identical except that the first yields more of the cash reward than the second, the first will always be chosen (i.e., preferred) over the second by an autonomous individual. An economist would say utility is a monotone increasing function of the cash reward.

Saliency: The cash rewards in an experiment should have motivational relevance. Subject are guaranteed the right to claim a reward which is increasing in the goods outcomes, and decreasing in the bads outcomes. That is, some decisions have higher rewards than others, and the mapping of decisions into rewards is well-defined and consistent.

Not all cash rewards are salient. For example, a flat fee is often used to compensate subjects for participating in psychology experiments. This type of reward is non-salient: it is a flat fee that is independent of the decisions made by the participant. The cumulative earnings of a subject over the course of an economics experiment are salient, as they are based on experimental outcomes and will vary as the subject's decisions vary.

Dominance: To ensure that control over preferences for the cash rewards is maintained, the reward structure must dominate any subjective costs (or values) associated with participation in the activities of an experiment.

All individual actions have subjective costs, even simple tasks like pressing keys on a computer keyboard. For example, suppose a subject was repeatedly asked to press either the Enter key or the Backspace key. Paying the subject $0.01 each time she presses the Enter key and $0.02 she presses the Backspace key would be a salient reward in a medium in which she is non-satiated. A simple theory might predict the subject would always press the Enter key and never the Backspace key. But such a trivial payment may not be sufficient to dominate the subjective costs of the

exercise: the subject might sometimes press the Backspace key to relieve boredom.

Similarly, the complexity of the task must be considered. Activities that require extensive thought or calculations must be compensated appropriately, independent of nonsatiation and saliency. The discussion of saliency above referred to the choice between two costless alternatives.

Privacy: Each subject in an experiment is given information only on his/her own payoff alternatives. Individuals may bring egalitarian, altruistic, or other such preferences from everyday social life into the laboratory. Thus a participant's valuation of the reward medium will be interdependent of the rewards which others receive. This would result in a loss of control, as well-defined valuations may not be induced and individuals would not be autonomous, own-reward maximizers. (In certain specific applications, a researcher may want to investigate to what degree knowledge of others' payoff alternatives would affect outcomes.)

In economics experiments, cash rewards are designed so as to compensate subjects not only for their participation (i.e., achieve dominance), but also to compensate them for their opportunity cost (i.e., time that could be spent in the pursuit of leisure, knowledge, other income, etc.). A rule of thumb, the "going wage rate" for a typical person in the subject pool is used as the benchmark. For college students, this rate is approximately \$4–\$5 an hour. A different subject pool, like professional currency traders, may require substantially higher rewards.

A non-salient show-up fee, usually \$5–\$8 depending on subjects' opportunity cost, is also paid to the subjects. This payment is a reward to subjects for honoring their commitment. While this payment is substantial, it is a necessary cost: attrition and no-show rates are much higher in its absence. Cancellation of experiments due to insufficient subjects results in high dollar, time, and effort costs on the part of the researcher.

References cited in this appendix are included in the references to the main text.

Appendix C
Procedure and Non-computerized Instructions

Procedure and Non-computerized Instructions

The experiment has two parts: Part I and Part II. Part I is the training session. Part II is the data session.

PART I procedure (items 1–5).

1. Subjects arrive and are seated. Each subject is given an **Earnings Record** with a 4-digit subject number. The subjects fill out the name, ID, and date/time information at the top. The subjects then play **session #26, using the subject number on the Earnings Record**. When entering the subject number, they DO NOT enter any spaces or dashes.
2. Session #26 is a 2-round, 2 x 2 matrix practice session. It was added so that subjects did not inadvertently start the first training session without getting the Additional Instructions and the Consent Form.
3. A pencil/pen and a calculator is located at each station, as the subjects will be required to do some hand recording and calculations.. Seat subjects in a manner that makes it easy to avoid errors when giving them their session numbers.
4. After finishing session #26, and while the Profit Page is showing on the screen, subjects are given (a) Additional Instructions, (b) Earnings Record with subject number on it, and (c) Consent forms. The Consent Form refers to two sessions, so it' is not necessary to provide another Consent Form when they come back for the second session
5. When giving out the Additional Instructions, explicitly point out the "Screen Earnings" on the computer screen and referred to in the Additional Instructions, and the corresponding column on the Earnings Record. The Earnings Record has room for five sessions in Part I and six sessions in Part II. This is so they won't anticipate that there are only four sessions in each Part II.
6. The subjects read the Additional Instructions and then read and sign the Consent Form. After signing the consent form, the experimenter or assistant gives the subject a Session Number and a Fixed Deduction (see below). <u>DO NOT GIVE SUBJECTS THE ENTIRE SEQUENCE AT ONCE</u>, as we will not be able to ensure that the sequences are completed in the correct order.
7. Upon completion of a session, the subject raises his/her hand. The experimenter or assistant verifies that the Screen Earnings are correctly recorded, and the Net Earnings = Screen Earnings minus Fixed Deduction are correctly computed. (This reduces verification problems upon payment at the end of Part II). The subject gets a new session number, and starts again.
8. There are four random sequences in each Part. An equal number of subjects get each sequence. .Here are the random sequences for Part I (randomized by deck of four cards), Part II sequence is below.

Part I (Training sessions #21, #22, #23, #24)

Sequence Number and Fixed Deduction

	1	2	3	4
A	#23–$12	#21–$7	#22–$0	#24–$5
B	#22–$0	#23–$12	#24–$5	#21–$7
C	#21–$7	#24–$5	#23–$12	#22–$0
D	#24–$5	#22–$0	#21–$7	#23–$12

1. After completing all four sequences, the subjects are excused. Subjects are paid a $6 show-up fee at the start of Part I. But otherwise, the subjects are not paid after Part I. The appropriate Earnings Record is returned to each subject upon arrival for Part II. They are paid their total earnings at the end of Part II. This is explicitly stated in the consent form.

PART II Procedure

1. Upon arriving for Part II, the subjects are seated and given Earnings Record from Part I (each subject uses the same subject number in Parts I and II.). They then play **session #27**, using the **same subject number**. Like session #26, this is a 2 round, 2 x 2 matrix session designed to control their progress, and to refresh their memory regarding the instructions.
2. After completing session #27, and while the Profit Page is showing on the screen, subjects are given a copy of the **Additional Instructions** (identical to those in Part I). The subjects are then given the first Session Number and Fixed Deduction, and begin.
3. As before, subjects are not given the entire session sequence at once, to ensure that they complete them in the correct order. Prior to giving the subject the new session number, the experimenter or assistant should verify that the subject correctly recorded data from the screen, and calculated Net Earnings correctly. After completing all four sessions in Part II, the subject is paid and excused.

There are four random sequences in Part II. An equal number of subjects get each sequence. .Here are the random sequences for Part II (randomized by deck of four cards):

Part II **(Data sessions #17, #18, #19, #20)**

Sequence Number and Fixed Deduction

	1	2	3	4
F	#20–$27	#17–$17	#19–$20	#18–$18
G	#17–$17	#19–$20	#18–$18	#20–$27
H	#18–$18	#20–$27	#17–$17	#19–$20
I	#19–$20	#18–$18	#20–$27	#17–$17

Additional Instructions

Earnings

In today's experiment, you will use an Earnings Record to keep track of your cash earnings. Please take a moment to examine the Earnings Record that you have been given with these instructions.

You will complete several different sessions. At the end of each session, you will calculate your earnings as follows:

1. On your Earnings Record, you will record your **Screen Earnings** from your computer screen. This total U.S. Dollar ($) amount is shown in the lower right corner of your computer screen.
2. Subtract the **Fixed Deduction** shown on your Earnings Record.
3. Enter the resulting **Net Earnings** on the blank provided.

After completing all sessions, you will sum your Net Earnings from all sessions, and enter this total as your **Total Net Earnings** from today's experiment.

You will be paid your total cash earnings after completing both Part I and Part II.

After you have calculated your earnings at the end of each session, RAISE YOUR HAND. An assistant will verify that you have recorded your earnings correctly, and then provide you with a new Session Number for the next session.

4-Minute Time Limit per Round

If you decline the Fixed Payoff, and decide to choose cells from the matrix, then you must click the END ROUND button before the 4-minute clock expires, or YOUR EARNINGS WILL BE $0.00 FOR THAT ROUND. Even if you choose some cells in the matrix, those choices will not be recorded by the computer unless you click the END ROUND button.

It is very important that you understand this time constraint. Please raise your hand if you have a question or do not understand this time constraint.

Consent Form

You have been given two copies of a Consent Form. After you have finished these Additional Instructions, please read, sign, and date one copy. The second copy is for you to keep, if you wish. If you do not wish to keep a copy, just leave it by your computer terminal.

AFTER YOU HAVE SIGNED YOUR CONSENT FORM, PLEASE RAISE YOUR HAND TO BEGIN THE FIRST SESSION FOR MONEY.

Earnings Record Subject Number: _____ - ___ - _________

Name (print clearly): ____________________________________

ID # (print clearly): ____________________________________

Part I. Date: _______________ Time: __________

	Session #	Screen Earnings	-	Fixed Deduction	=	Net Earnings
A.	________	$__________	-	$__________	=	$__________
B.	________	$__________	-	$__________	=	$__________
C.	________	$__________	-	$__________	=	$__________
D.	________	$__________	-	$__________	=	$__________
E.	________	$__________	-	$__________	=	$__________
				Total Net Earnings =		$__________

Part II. Date: _______________ Time: __________

	Session #	Screen Earnings	-	Fixed Deduction	=	Net Earnings
F.	________	$__________	-	$__________	=	$__________
G.	________	$__________	-	$__________	=	$__________
H.	________	$__________	-	$__________	=	$__________
I.	________	$__________	-	$__________	=	$__________
J.	________	$__________	-	$__________	=	$__________
K.	________	$__________	-	$__________	=	$__________
				Total Net Earnings =		$__________

TOTAL EARNINGS (Part I + Part II) = $____________

CONSENT TO PARTICIPATE IN AN EXPERIMENTAL STUDY

TITLE: Experimental Study of Economic Decision Making

INVESTIGATOR: Mark Van Boening, Ph.D. Phone: (662) 915-5841
Holman 233, School of Business Administration
University of Mississippi
University, MS 38677

DESCRIPTION: This is a study about how people make economic decisions. Participation involves a series of decisions that are made via a computer program.
RISKS, BENEFITS, AND PAYMENTS: I understand that the $6 per-day show-up fee is my only guaranteed benefit for participating in this experiment. However, I understand that the average total payments to participants who complete this experiment are sufficient to compensate for the time required. I understand that the experiment consists of two parts (Part I and Part II) that will be conducted on two separate days, and each part will last approximately two hours. I also understand that my total earnings will be paid to me in cash upon completion of Part II of the study.
CONFIDENTIALITY: Any information obtained about me from this research will be kept confidential. It will not be possible to infer that I participated in this study from any published material that results from this study.
RIGHT TO WITHDRAW: I understand that I may discontinue my participation in the experiment at any time. If I do decide to leave the experiment before its conclusion, I will keep the $6 show-up fee.
Institutional Review Board (IRB) APPROVAL: This project was reviewed by the University of Mississippi's Institutional Review Board (IRB), which determined that this study meets the ethical obligations required by federal law and University standards. If you have any questions, concerns, or reports regarding this study, please contact the IRB at 915-7482.
VOLUNTARY CONSENT: I certify that I have read the preceding or it has been read to me and that I understand its content. I certify that the decision-making task and the computer program have been explained to me in detail. I certify that the manner in which I earn money as a result of my decisions has been explained to me in detail. I acknowledge that I have been given the opportunity to ask questions regarding participation in this experiment, including the hazards, discomforts, benefits, or any other aspects that were not clear to me, and that my questions were fully answered. I understand that further questions will be answered by Dr. Van Boening or one of his assistants. A copy of this written consent has been given to me. My signature below indicates that I freely consent to participate in this experimental study.

________________ Date

____________________________ Participant Signature

____________________________ Witness

Appendix D
Matrices and Heuristics

Matrices and Heuristics

Decision matrices viewed by subject

Session S1

Round 1

736	798	141	967	573
581	113	473	885	791
622	785	877	151	148
361	834	812	956	634
372	739	437	428	522

Round 2

369	848	304	196	190
661	843	726	1000	193
684	631	983	709	820
338	988	320	114	356
352	921	581	618	141

Round 3

366	462	469	287	916
444	351	472	268	335
371	245	742	626	807
955	247	394	173	441
983	683	670	513	361

Round 4

928	605	590	563	150
669	726	925	517	320
666	923	488	418	982
486	852	711	465	155
188	120	553	343	452

Round 5

429	667	556	779	167
541	588	452	637	195
240	241	197	850	399
527	946	806	117	216
332	690	514	290	100

Round 6

584	273	735	462	186
692	712	937	516	631
590	509	578	543	253
845	422	181	287	936
174	235	783	397	188

Round 7

500	707	812	407	630
346	331	368	140	780
886	181	312	535	936
776	128	533	286	398
346	391	329	879	589

Round 8

173	932	298	593	844
672	659	995	932	706
469	413	218	585	750
965	234	126	466	998
203	532	411	863	406

Round 9

546	589	305	434	301
472	834	658	373	627
726	587	541	364	427
261	485	713	235	889
481	559	899	577	531

Session S2

Round 1

807	393	889	727	559
145	976	475	462	466
567	825	211	115	196
782	708	960	251	349
821	916	818	248	679

Round 2

865	392	891	628	333
549	795	650	939	334
269	296	437	566	261
908	503	451	398	413
436	313	875	882	102

Round 3

769	831	406	634	987
858	768	740	962	670
351	494	381	319	640
733	170	820	947	913
465	470	237	203	618

Round 4

321	321	624	688	498
875	441	289	911	543
168	458	171	309	793
495	574	907	956	852
785	344	200	862	445

Round 5

276	190	993	778	109
394	285	525	903	237
472	724	104	841	440
238	555	484	259	270
658	265	360	198	983

Round 6

886	125	506	287	483
624	846	600	429	616
757	806	824	617	145
231	813	608	410	593
332	400	283	576	286

Round 7

967	826	115	362	828
941	991	406	459	379
994	333	724	604	439
856	257	199	380	461
469	726	199	366	858

Round 8

469	682	511	354	786
753	565	915	432	623
694	301	355	113	646
466	625	701	365	342
956	774	902	987	558

Session S3

Round 1

919	969	625	384	390
952	108	828	472	167
689	959	136	560	468
113	166	149	761	616
696	364	608	506	788

Round 2

623	750	163	266	744
687	725	324	313	699
828	758	956	934	796
476	273	839	332	784
818	797	298	331	378

Round 3

843	599	226	483	443
748	420	155	269	537
907	284	671	546	593
301	622	856	977	707
421	668	677	793	134

Round 4

684	795	749	982	387
910	423	557	356	817
407	471	256	657	257
206	774	351	376	370
483	493	179	868	166

Round 5

545	222	846	387	719
508	395	599	641	785
639	785	647	638	333
127	665	271	791	595
387	968	913	744	559

Round 6

609	567	224	186	403
354	625	689	654	731
475	519	238	733	292
416	129	278	496	140
976	440	438	479	898

Round 7

139	289	517	585	152
513	522	414	665	348
766	882	325	179	966
780	846	827	741	395
841	470	590	332	684

Round 8

427	481	643	459	574
433	656	171	626	449
394	318	140	359	102
293	718	238	854	326
291	632	322	909	247

Round 9

681	217	866	711	297
984	613	188	457	759
381	647	455	852	910
317	650	841	490	296
892	725	342	853	985

Round 10

970	241	148	368	580
885	679	556	972	126
571	652	149	112	746
686	869	438	686	383
511	431	507	653	984

Session S4

Round 1

161	462	462	393	304
663	446	649	107	959
397	285	595	806	270
351	889	757	930	476
715	236	211	370	427

Round 2

393	910	949	643	159
983	128	521	597	242
622	814	752	516	190
574	748	458	685	146
221	320	309	790	592

Round 3

962	309	851	664	247
304	866	842	975	324
412	162	998	479	648
902	220	315	151	429
533	969	697	891	577

Round 4

927	781	427	491	825
593	617	475	241	740
965	501	429	975	327
789	141	669	348	812
465	135	262	153	884

Round 5

986	551	755	924	765
344	897	907	851	609
517	616	238	801	248
923	480	797	800	381
932	838	701	527	522

Round 6

906	987	893	933	147
880	503	622	145	914
446	802	876	843	990
970	378	829	306	336
553	171	792	348	586

Round 7

409	628	515	458	628
292	872	357	813	695
281	179	851	826	626
217	280	377	648	153
645	671	978	421	857

Round 8

153	872	803	859	647
236	151	133	289	190
385	908	223	304	950
493	316	703	556	445
481	147	337	658	413

Round 9

136	326	592	289	493
902	599	439	391	843
545	140	233	482	617
467	834	761	768	793
939	523	299	207	365

Round 10

164	670	248	365	980
662	245	550	479	184
553	917	130	563	803
720	433	774	104	140
417	834	857	700	970

Round 11

1000	971	343	732	282
721	726	128	849	194
720	898	392	178	662
262	215	913	837	168
257	236	316	832	661

Heuristics

See text for description of heuristics.

S1 Round 1	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	7	3	5	7	7
Payoff	2348	2475	2197	2460	2499	2535	2540
Cell value sum	1923	1996	1714	2000	1999	1996	2000
Remaining value limit	77	4	286	0	1	4	0
	967	573	428	967	622	634	437
	956	522	372	885	437	437	428
		473	361	148	428	372	372
		428	151		361	151	361
			148		151	148	148
			141			141	141
			113			113	113

S1 Round 2	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	8	3	5	7	8
Payoff	2426	2468	2315	2458	2495	2532	2553
Cell value sum	1988	1990	1796	1998	1996	1993	1994
Remaining value limit	12	10	204	2	4	7	6
	1000	684	338	988	581	631	356
	988	581	320	820	369	338	352
		369	304	190	356	304	338
		356	196		352	196	304
			193		338	193	196
			190			190	193
			141			141	141
			114				114

S1 Round 3	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	7	3	5	7	7
Payoff	2366	2478	2427	2452	2494	2535	2540
Cell value sum	1938	1998	1906	1993	1995	1996	2000
Remaining value limit	62	2	94	7	5	4	0
	983	626	351	983	513	441	371
	955	469	335	742	394	335	361
		462	287	268	371	287	335
		441	268		366	268	268
			247		351	247	247
			245			245	245
			173			173	173

S1	Round 4	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
	number of cells	2	4	7	3	5	7	7
	payoff	2332	2476	2173	2447	2498	2533	2540
	cell value sum	1910	1997	1694	1989	1998	1994	2000
	remaining value limit	90	3	306	11	2	6	0
		982	563	418	982	465	488	517
		928	517	343	852	452	418	452
			465	320	155	418	343	418
			452	188		343	320	188
				155		320	155	155
				150			150	150
				120			120	120

S1	Round 5	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
	number of cells	2	4	9	3	5	9	9
	payoff	2195	2475	2296	2452	2490	2580	2580
	cell value sum	1796	1996	1763	1993	1992	2000	2000
	remaining value limit	204	4	237	7	8	0	0
		946	588	290	946	527	527	527
		850	527	241	806	514	241	241
			452	240	241	452	240	240
			429	216		399	216	216
				197			197	197
				195			195	195
				167			167	167
				117			117	117
				100			100	100

S1	Round 6	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
	number of cells	2	4	8	3	5	7	8
	payoff	2288	2468	2292	2450	2496	2540	2560
	cell value sum	1873	1990	1777	1992	1997	2000	2000
	remaining value limit	127	10	223	8	3	0	0
		937	543	287	936	578	783	397
		936	516	273	783	462	253	287
			509	253	273	397	235	273
			422	235		287	188	253
				188		273	186	235
				186			181	188
				181			174	186
				174				181

S1 Round 7	H_S	M_S	L_S	H_A	M_A	L_A	Optimal 1	Optimal 2
Number of cells	2	4	7	3	5	7	7	7
Payoff	2226	2470	2188	2455	2496	2534	2540	2540
Cell value sum	1822	1992	1707	1996	1997	1995	2000	2000
Remaining value limit	178	8	293	4	3	5	0	0
	936	589	331	936	500	391	500	407
	886	535	329	879	407	368	391	398
		500	312	181	398	329	331	329
		368	286		346	312	329	312
			181		346	286	181	286
			140			181	140	140
			128			128	128	128

S1 Round 8	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	7	3	5	7	7
Payoff	2432	2479	2130	2458	2493	2533	2538
Cell value sum	1993	1999	1658	1998	1994	1994	1998
Remaining value limit	7	1	342	2	6	6	2
	998	585	406	932	466	532	466
	995	532	298	863	413	413	406
		469	234	203	411	298	298
		413	218		406	234	234
			203		298	218	218
			173			173	203
			126			126	173

S1 Round 9	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	6	3	5	6	6
Payoff	2186	2476	2327	2453	2500	2516	2516
Cell value sum	1788	1997	1839	1994	2000	1997	1997
Remaining value limit	212	3	161	6	0	3	3
	899	559	373	899	531	531	531
	889	485	364	834	427	364	364
		481	305	261	373	305	305
		472	301		364	301	301
			261		305	261	261
			235			235	235

S2 Round 1	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	8	3	5	8	8
Payoff	2523	2793	3090	2689	2892	3188	3188
Cell value sum	1936	1994	1908	1991	1993	1990	1990
Remaining value limit	64	6	92	9	7	10	10
	976	567	393	960	679	475	475
	960	559	349	916	466	349	349
		475	251	115	349	251	251
		393	248		251	248	248
			211		248	211	211
			196			196	196
			145			145	145
			115			115	115

S2 Round 2	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	7	3	5	7	7
Payoff	2416	2794	2990	2694	2898	3084	3092
Cell value sum	1847	1995	1908	1995	1998	1987	1993
Remaining value limit	153	5	92	5	2	13	7
	939	628	334	939	451	413	398
	908	503	333	795	437	333	334
		451	313	261	436	313	333
		413	296		413	296	296
			269		261	269	269
			261			261	261
			102			102	102

S2 Round 3	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	6	3	5	6	6
Payoff	2539	2786	2593	2688	2883	2982	2983
Cell value sum	1949	1988	1661	1990	1986	1985	1986
Remaining value limit	51	12	339	10	14	15	14
	987	670	381	962	470	494	470
	962	618	351	858	465	381	406
		381	319	170	381	351	351
		319	237		351	319	319
			203		319	237	237
			170			203	203

S2 Round 4	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
number of cells	2	4	7	3	5	7	7
payoff	2440	2793	2835	2699	2896	3089	3089
cell value sum	1867	1994	1779	1999	1997	1991	1991
remaining value limit	133	6	221	1	3	9	9
	956	543	321	956	458	498	498
	911	498	321	875	445	344	344
		495	309	168	441	321	321
		458	289		344	289	289
			200		309	200	200
			171			171	171
			168			168	168

S2 Round 5	H_S	M_S	L_S	H_A	M_A	L_A	Optimal 1	Optimal 2
number of cells	2	4	9	3	5	9	9	9
payoff	2571	2790	3144	2700	2894	3293	3299	3299
cell value sum	1976	1992	1870	2000	1995	1994	1999	1999
remaining value limit	24	8	130	0	5	6	1	1
	993	555	270	993	525	394	360	394
	983	525	265	903	440	265	276	270
		472	259	104	394	259	265	259
		440	238		360	238	259	238
			237		276	237	238	237
			198			198	198	198
			190			190	190	190
			109			109	109	109
			104			104	104	104

S2 Round 6	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
number of cells	2	4	7	3	5	7	7
payoff	2278	2793	2727	2689	2889	3094	3100
cell value sum	1732	1994	1689	1991	1991	1995	2000
remaining value limit	268	6	311	9	9	5	0
	886	576	332	846	506	593	429
	846	506	287	813	483	332	400
		483	286	332	429	286	332
		429	283		287	283	286
			231		286	231	283
			145			145	145
			125			125	125

S2 Round 7	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	7	3	5	7	7
Payoff	2582	2792	2897	2698	2899	3096	3100
Cell value sum	1985	1993	1831	1998	1999	1997	2000
Remaining value limit	15	7	169	2	1	3	0
	994	604	366	941	459	459	380
	991	469	362	858	439	406	379
		461	333	199	406	362	366
		459	257		362	257	362
			199		333	199	199
			199			199	199
			115			115	115

S2 Round 8	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	6	3	5	6	6
Payoff	2532	2799	2796	2681	2893	2999	2999
Cell value sum	1943	1999	1830	1984	1994	1999	1999
Remaining value limit	57	1	170	16	6	1	1
	987	565	355	956	511	511	511
	956	558	354	915	432	365	365
		511	342	113	355	355	355
		365	301		354	354	354
			113		342	301	301
						113	113

S3 Round 1	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	9	3	5	8	8
Payoff	2354	2480	2552	2449	2496	2560	2560
Cell value sum	1928	2000	1977	1991	1997	2000	2000
Remaining value limit	72	0	23	9	3	0	0
	969	608	390	959	506	689	689
	959	560	384	919	472	472	472
		468	364	113	468	167	167
		364	167		384	166	166
			166		167	149	149
			149			136	136
			136			113	113
			113			108	108
			108				

S3 Round 2	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	7	3	5	6	7
Payoff	2308	2478	2502	2458	2499	2520	2524
Cell value sum	1890	1998	1968	1998	1999	2000	1987
Remaining value limit	110	2	32	2	1	0	13
	956	699	331	839	699	687	332
	934	623	324	828	332	313	331
		378	313	331	331	298	324
		298	298		324	273	298
			273		313	266	273
			266			163	266
			163				163

S3 Round 3	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	7	3	5	7	7
Payoff	2301	2479	2287	2447	2494	2529	2533
Cell value sum	1884	1999	1789	1989	1995	1991	1994
Remaining value limit	116	1	211	11	5	9	6
	977	599	420	907	546	622	483
	907	537	301	856	443	301	443
		443	284	226	421	284	284
		420	269		301	269	269
			226		284	226	226
			155			155	155
			134			134	134

S3 Round 4	H_S	M_S	L_S	H_A	M_A	L_A	Optimal 1	Optimal 2
Number of cells	2	4	7	3	5	7	7	7
Payoff	2310	2478	2265	2459	2496	2529	2540	2540
Cell value sum	1892	1998	1771	1999	1997	1991	2000	2000
Remaining value limit	108	2	229	1	3	9	0	0
	982	657	356	817	471	557	376	471
	910	483	351	795	407	370	370	370
		471	257	387	387	257	356	351
		387	256		376	256	257	257
			206		356	206	256	206
			179			179	206	179
			166			166	179	166

S3 Round 5	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	6	3	5	6	6
Payoff	2297	2479	2192	2448	2499	2516	2516
Cell value sum	1881	1999	1727	1990	1999	1997	1997
Remaining value limit	119	1	273	10	1	3	3
	968	559	387	913	559	595	595
	913	545	387	744	395	395	395
		508	333	333	387	387	387
		387	271		387	271	271
			222		271	222	222
			127			127	127

S3 Round 6	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	8	3	5	8	8
Payoff	2289	2479	2369	2459	2499	2547	2547
Cell value sum	1874	1999	1841	1999	1999	1989	1989
Remaining value limit	126	1	159	1	1	11	11
	976	567	354	976	475	440	440
	898	519	292	731	440	354	354
		475	278	292	438	278	278
		438	238		354	238	238
			224		292	224	224
			186			186	186
			140			140	140
			129			129	129

S3 Round 7	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	7	3	5	7	7
Payoff	2258	2469	2257	2449	2494	2535	2539
Cell value sum	1848	1991	1764	1991	1995	1996	1999
Remaining value limit	152	9	236	9	5	4	1
	966	590	348	966	513	517	513
	882	517	332	846	414	395	395
		470	325	179	395	325	332
		414	289		348	289	289
			179		325	179	179
			152			152	152
			139			139	139

S3 Round 8	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	8	3	5	8	8
Payoff	2156	2479	2320	2460	2493	2550	2560
Cell value sum	1763	1999	1800	2000	1994	1992	2000
Remaining value limit	237	1	200	0	6	8	0
	909	626	318	718	449	481	359
	854	574	293	656	433	322	326
		481	291	626	427	291	318
		318	247		359	247	293
			238		326	238	291
			171			171	171
			140			140	140
			102			102	102

S3 Round 9	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	6	3	5	6	6
Payoff	2403	2480	2108	2448	2500	2515	2518
Cell value sum	1969	2000	1657	1990	2000	1996	1998
Remaining value limit	31	0	343	10	0	4	2
	985	711	342	910	490	681	490
	984	490	317	892	457	317	381
		457	297	188	455	297	317
		342	296		381	296	297
			217		217	217	296
			188			188	217

S3 Round 10	H_S	M_S	L_S	H_A	M_A	L_A	Optimal 1	Optimal 2
number of cells	2	4	8	3	5	7	7	7
payoff	2387	2480	2510	2454	2500	2536	2540	2540
cell value sum	1956	2000	1958	1995	2000	1997	2000	2000
remaining value limit	44	0	42	5	0	3	0	0
	984	679	431	885	507	571	653	571
	972	507	383	869	438	431	571	511
		431	368	241	431	368	241	383
		383	241		383	241	149	149
			149		241	148	148	148
			148			126	126	126
			126			112	112	112
			112					

S4 Round 1	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	8	3	5	8	8
Payoff	2467	2794	3110	2695	2889	3189	3189
Cell value sum	1889	1995	1925	1996	1991	1991	1991
Remaining value limit	111	5	75	4	9	9	9
	959	595	351	959	462	370	370
	930	476	304	930	462	351	351
		462	285	107	393	285	285
		462	270		370	270	270
			236		304	236	236
			211			211	211
			161			161	161
			107			107	107

S4 Round 2	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	8	3	5	8	8
Payoff	2518	2793	2858	2696	2895	3198	3200
Cell value sum	1932	1994	1715	1997	1996	1998	2000
Remaining value limit	68	6	285	3	4	2	0
	983	622	320	814	516	592	521
	949	521	309	790	458	320	393
		458	242	393	393	242	242
		393	221		320	221	221
			190		309	190	190
			159			159	159
			146			146	146
			128			128	128

S4 Round 3	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	7	3	5	7	7
Payoff	2568	2800	2750	2688	2892	3090	3098
Cell value sum	1973	2000	1708	1990	1993	1992	1998
Remaining value limit	27	0	292	10	7	8	2
	998	664	315	962	533	479	429
	975	533	309	866	429	429	412
		479	304	162	412	304	315
		324	247		315	247	309
			220		304	220	220
			162			162	162
			151			151	151

S4 Round 4	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
number of cells	2	4	7	3	5	7	7
payoff	2528	2798	2628	2692	2895	3099	3100
cell value sum	1940	1998	1607	1993	1996	1999	2000
remaining value limit	60	2	393	7	4	1	0
	975	593	348	927	465	740	593
	965	501	327	825	429	327	475
		475	262	241	427	262	262
		429	241		348	241	241
			153		327	153	153
			141			141	141
			135			135	135

S4 Round 5	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
number of cells	2	4	5	3	5	5	5
payoff	2502	2796	2529	2695	2893	2896	2900
cell value sum	1918	1997	1691	1996	1994	1997	2000
remaining value limit	82	3	309	4	6	3	0
	986	609	480	897	551	616	616
	932	527	381	851	480	551	517
		480	344	248	381	344	381
		381	248		344	248	248
			238		238	238	238

S4 Round 6	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
number of cells	2	4	7	3	5	7	7
payoff	2572	2788	2897	2693	2887	3098	3098
cell value sum	1977	1990	1831	1994	1989	1998	1998
remaining value limit	23	10	169	6	11	2	2
	990	586	378	933	553	503	503
	987	553	348	914	446	378	378
		503	336	147	348	348	348
		348	306		336	306	306
			171		306	171	171
			147			147	147
			145			145	145

S4 Round 7							
number of cells	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
payoff	2	4	7	3	5	7	7
cell value sum	2420	2795	2811	2700	2893	3092	3100
remaining value limit	1850	1996	1759	2000	1994	1993	2000
	150	4	241	0	6	7	0
	978	695	357	857	515	357	458
	872	515	292	851	421	292	421
		409	281	292	409	280	292
		377	280		357	217	280
			217		292	179	217
			179			153	179
			153				153

S4 Round 8	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
number of cells	2	4	9	3	5	9	9
payoff	2430	2795	3091	2689	2900	3293	3300
cell value sum	1858	1996	1826	1991	2000	1994	2000
remaining value limit	142	4	174	9	0	6	0
	950	658	304	950	493	445	385
	908	556	289	908	481	316	316
		445	236	133	385	236	289
		337	223		337	223	236
			190		304	190	190
			153			153	153
			151			151	151
			147			147	147
			133			133	133

S4 Round 9	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	8	3	5	8	8
Payoff	2409	2800	3194	2693	2886	3194	3194
Cell value sum	1841	2000	1995	1994	1988	1995	1995
Remaining value limit	159	0	5	6	12	5	5
	939	545	365	902	467	365	365
	902	523	326	793	439	326	326
		493	299	299	391	299	299
		439	289		365	289	289
			233		326	233	233
			207			207	207
			140			140	140
			136			136	136

S4 Round 10	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	9	3	5	9	9
Payoff	2540	2799	3296	2689	2898	3296	3296
Cell value sum	1950	1999	1997	1991	1998	1997	1997
Remaining value limit	50	1	3	9	2	3	3
	980	553	417	970	553	417	417
	970	550	365	917	479	365	365
		479	248	104	417	248	248
		417	245		365	245	245
			184		184	184	184
			164			164	164
			140			140	140
			130			130	130
			104			104	104

S4 Round 11	H_S	M_S	L_S	H_A	M_A	L_A	Optimal
Number of cells	2	4	9	3	5	9	9
Payoff	2566	2796	3204	2696	2893	3277	3300
Cell value sum	1971	1997	1920	1997	1994	1981	2000
Remaining value limit	30	3	80	3	6	19	0
	1000	662	282	971	661	343	316
	971	661	262	898	392	262	282
		392	257	128	343	257	262
		282	236		316	236	257
			215		282	215	215
			194			194	194
			178			178	178
			168			168	168
			128			128	128

Appendix E
SAS Regression Output

SAS Regression Output

Table E-1. "Earnings Ratio" Regression Output

Source	Degrees of Freedom	Sum of Squares	Mean Square	F statistic, p-value	R^2, Adjusted R^2
		Analysis of Variance			
Model	94	29.39607	0.31272	196.89	0. 8627
Error	2945	4.67763	0.00159	<.0001	0. 8583
Corrected Total	3039	34.07370			

Root MSE	Dependent Mean	Coefficient of Variation
0.03985	0.94678	4.20940

Parameter	Estimated coefficient	Standard Error	t-statistic	p-value
β_0	1.00954	0.00692	145.80	<.0001
β_F	-0.18580	0.00434	-42.78	<.0001
β_T	-0.95534	0.00847	-112.73	<.0001
β_{S2}	-0.02598	0.00219	-11.88	<.0001
β_{S3}	-0.00162	0.00209	-0.78	0.4368
β_{S4}	-0.03900	0.00209	-18.66	<.0001
β_{R2}	-0.00049	0.00315	-0.16	0.8762
β_{R3}	0.00482	0.00315	1.53	0.1261
β_{R4}	0.00025	0.00315	0.08	0.9361
β_{R5}	0.00291	0.00315	0.92	0.3560
β_{R6}	0.00166	0.00315	0.53	0.5989
β_{R7}	0.00328	0.00315	1.04	0.2977
β_{R8}	-0.00086	0.00315	-0.27	0.7845
β_{R9}	-0.00310	0.00343	-0.90	0.3671
β_{R10}	-0.00430	0.00393	-1.09	0.2747
β_{R11}	-0.00468	0.00514	-0.91	0.3629
β_{Sub2}	-0.00460	0.00915	-0.50	0.6147
β_{Sub3}	-0.01758	0.00914	-1.92	0.0547
β_{Sub4}	-0.10625	0.00914	-11.62	<.0001
β_{Sub5}	-0.06743	0.00914	-7.37	<.0001
β_{Sub6}	0.00300	0.00914	0.33	0.7432
β_{Sub7}	0.00220	0.00914	0.24	0.8099
β_{Sub8}	-0.04853	0.00915	-5.31	<.0001
β_{Sub9}	-0.00162	0.00919	-0.18	0.8604

β_{Sub10}	-0.01669	0.00914	-1.83	0.0681
β_{Sub11}	0.00146	0.00914	0.16	0.8732
β_{Sub12}	-0.01443	0.00914	-1.58	0.1147
β_{Sub13}	-0.00805	0.00915	-0.88	0.3790
β_{Sub14}	0.00034	0.00914	0.04	0.9705
β_{Sub15}	0.00202	0.00914	0.22	0.8249
β_{Sub16}	-0.06677	0.00915	-7.30	<.0001
β_{Sub17}	0.00255	0.00914	0.28	0.7803
β_{Sub18}	0.00052	0.00914	0.06	0.9543
β_{Sub19}	-0.00154	0.00914	-0.17	0.8664
β_{Sub20}	-0.02482	0.00915	-2.71	0.0067
β_{Sub21}	-0.01463	0.00914	-1.60	0.1097
β_{Sub22}	-0.04169	0.00914	-4.56	<.0001
β_{Sub23}	0.00131	0.00914	0.14	0.8858
β_{Sub24}	-0.06703	0.00915	-7.32	<.0001
β_{Sub25}	-0.01982	0.00914	-2.17	0.0303
β_{Sub26}	0.00241	0.00915	0.26	0.7924
β_{Sub27}	-0.00012	0.00914	-0.01	0.9894
β_{Sub28}	-0.00463	0.00914	-0.51	0.6126
β_{Sub29}	-0.01299	0.00914	-1.42	0.1553
β_{Sub30}	0.00032	0.00915	0.03	0.9721
β_{Sub31}	0.00124	0.00914	0.14	0.8924
β_{Sub32}	-0.01606	0.00914	-1.76	0.0791
β_{Sub33}	-0.01606	0.00914	-1.76	0.0791
β_{Sub34}	0.00083	0.00914	0.09	0.9273
β_{Sub35}	-0.05040	0.00914	-5.51	<.0001
β_{Sub36}	-0.04548	0.00919	-4.95	<.0001
β_{Sub37}	-0.01384	0.00914	-1.51	0.1302
β_{Sub38}	-0.15961	0.00923	-17.29	<.0001
β_{Sub39}	-0.07873	0.00915	-8.61	<.0001
β_{Sub40}	-0.04876	0.00915	-5.33	<.0001
β_{Sub41}	-0.05821	0.00915	-6.36	<.0001
β_{Sub42}	-0.01527	0.00914	-1.67	0.0951
β_{Sub43}	-0.03517	0.00914	-3.85	0.0001
β_{Sub44}	-0.08057	0.00914	-8.81	<.0001
β_{Sub45}	-0.05476	0.00914	-5.99	<.0001
β_{Sub46}	-0.01899	0.00920	-2.06	0.0391
β_{Sub47}	-0.04525	0.00918	-4.93	<.0001
β_{Sub48}	-0.07498	0.00914	-8.20	<.0001
β_{Sub49}	-0.04983	0.00916	-5.44	<.0001
β_{Sub50}	-0.04265	0.00915	-4.66	<.0001

β_{Sub51}	-0.02987	0.00914	-3.27	0.0011
β_{Sub52}	-0.04831	0.00915	-5.28	<.0001
β_{Sub53}	-0.03883	0.00914	-4.25	<.0001
β_{Sub54}	-0.05887	0.00915	-6.44	<.0001
β_{Sub55}	-0.05698	0.00915	-6.23	<.0001
β_{Sub56}	-0.12341	0.00915	-13.48	<.0001
β_{Sub57}	-0.02504	0.00914	-2.74	0.0062
β_{Sub58}	-0.02333	0.00914	-2.55	0.0108
β_{Sub59}	-0.07089	0.00915	-7.75	<.0001
β_{Sub60}	-0.04356	0.00915	-4.76	<.0001
β_{Sub61}	-0.01255	0.00915	-1.37	0.1701
β_{Sub62}	0.00437	0.00914	0.48	0.6328
β_{Sub63}	-0.07072	0.00914	-7.73	<.0001
β_{Sub64}	-0.04792	0.00914	-5.24	<.0001
β_{Sub65}	-0.00466	0.00915	-0.51	0.6102
β_{Sub66}	-0.04716	0.00915	-5.15	<.0001
β_{Sub67}	-0.02097	0.00914	-2.29	0.0219
β_{Sub68}	-0.05869	0.00925	-6.35	<.0001
β_{Sub69}	-0.01337	0.00914	-1.46	0.1436
β_{Sub70}	-0.02974	0.00914	-3.25	0.0012
β_{Sub71}	-0.00639	0.00918	-0.70	0.4865
β_{Sub72}	-0.05416	0.00915	-5.92	<.0001
β_{Sub73}	-0.01995	0.00914	-2.18	0.0292
β_{Sub74}	-0.00809	0.00915	-0.88	0.3766
β_{Sub75}	-0.00544	0.00914	-0.60	0.5517
β_{Sub76}	-0.14933	0.00914	-16.33	<.0001
β_{Sub77}	-0.00866	0.00915	-0.95	0.3440
β_{Sub78}	-0.00009	0.00915	-0.01	0.9924
β_{Sub79}	-0.02579	0.00920	-2.80	0.0051
β_{Sub80}	-0.07020	0.00914	-7.68	<.0001

F tests for restrictions

Test	Source	d.f.	Mean Square	F-statistic, p-value
H_0: $\beta_{S2} = \beta_{S3} = \beta_{S4} = 0$	Numerator	3	0.27632	173.97
	Denominator	2945	0.00159	<.0001
H_0: $\beta_{R2} = \beta_{R3} = \ldots = \beta_{R11} = 0$	Numerator	10	0.00197	1.24
	Denominator	2945	0.00159	.2598
H_0: $\beta_{Sub2} = \beta_{Sub3} = \ldots = \beta_{Sub80} = 0$	Numerator	79	0.04468	28.13
	Denominator	2945	0.00159	<.0001

Table E-2. "Cells Ratio" Regression Output

Analysis of Variance

Source	Degrees of freedom	Sum of Squares	Mean Square	F statistic, p-value	R^2, Adjusted R^2
Model	94	175.59962	1.86808	111.23	0. 7802
Error	2945	49.46135	0.01680	<.0001	0. 7732
Corrected Total	3039	225.06098			

Root MSE	Dependent Mean	Coefficient of Variation
0.12960	0.77029	16.82437

Parameter	Estimated coefficient	Standard Error	t-statistic	p-value
β_0	0.98658	0.02252	43.82	<.0001
β_F	-0.73903	0.01412	-52.33	<.0001
β_T	-0.74120	0.02756	-26.90	<.0001
β_{S2}	0.01868	0.00711	2.63	0.0086
β_{S3}	0.02552	0.00679	3.76	0.0002
β_{S4}	0.01304	0.00680	1.92	0.0552
β_{R2}	-0.03354	0.01025	-3.27	0.0011
β_{R3}	-0.00647	0.01025	-0.63	0.5278
β_{R4}	-0.00152	0.01025	-0.15	0.8824
β_{R5}	0.00032	0.01025	0.03	0.9754
β_{R6}	-0.04079	0.01025	-3.98	<.0001
β_{R7}	0.00688	0.01025	0.67	0.5020
β_{R8}	-0.02201	0.01025	-2.15	0.0318
β_{R9}	-0.00559	0.01117	-0.50	0.6166
β_{R10}	-0.00268	0.01279	-0.21	0.8341

β_{R11}	-0.02447	0.01671	-1.46	0.1431
β_{Sub2}	-0.00650	0.02974	-0.22	0.8271
β_{Sub3}	-0.11372	0.02973	-3.82	0.0001
β_{Sub4}	-0.49691	0.02973	-16.71	<.0001
β_{Sub5}	-0.37532	0.02973	-12.62	<.0001
β_{Sub6}	-0.01728	0.02973	-0.58	0.5611
β_{Sub7}	-0.03091	0.02973	-1.04	0.2986
β_{Sub8}	-0.30138	0.02974	-10.13	<.0001
β_{Sub9}	-0.04755	0.02989	-1.59	0.1117
β_{Sub10}	-0.18749	0.02973	-6.31	<.0001
β_{Sub11}	-0.03295	0.02973	-1.11	0.2679
β_{Sub12}	-0.10563	0.02973	-3.55	0.0004
β_{Sub13}	-0.07323	0.02974	-2.46	0.0139
β_{Sub14}	-0.00705	0.02973	-0.24	0.8126
β_{Sub15}	0.00386	0.02973	0.13	0.8966
β_{Sub16}	-0.48510	0.02976	-16.30	<.0001
β_{Sub17}	0.00799	0.02973	0.27	0.7882
β_{Sub18}	-0.01331	0.02973	-0.45	0.6543
β_{Sub19}	-0.04026	0.02973	-1.35	0.1758
β_{Sub20}	-0.25267	0.02974	-8.50	<.0001
β_{Sub21}	-0.09202	0.02973	-3.09	0.0020
β_{Sub22}	-0.29933	0.02973	-10.07	<.0001
β_{Sub23}	0.00094	0.02973	0.03	0.9748
β_{Sub24}	-0.49006	0.02977	-16.46	<.0001
β_{Sub25}	0.00668	0.02973	0.22	0.8222
β_{Sub26}	0.00739	0.02974	0.25	0.8037
β_{Sub27}	0.00423	0.02973	0.14	0.8869
β_{Sub28}	-0.07116	0.02973	-2.39	0.0168
β_{Sub29}	-0.09352	0.02973	-3.15	0.0017
β_{Sub30}	-0.02545	0.02974	-0.86	0.3922
β_{Sub31}	0.01128	0.02973	0.38	0.7045
β_{Sub32}	-0.04442	0.02973	-1.49	0.1352
β_{Sub33}	-0.08720	0.02973	-2.93	0.0034
β_{Sub34}	-0.00851	0.02973	-0.29	0.7747
β_{Sub35}	-0.33328	0.02973	-11.21	<.0001
β_{Sub36}	-0.06105	0.02988	-2.04	0.0411
β_{Sub37}	-0.08179	0.02973	-2.75	0.0060
β_{Sub38}	-0.51129	0.03001	-17.04	<.0001
β_{Sub39}	-0.56407	0.02974	-18.97	<.0001
β_{Sub40}	-0.38198	0.02976	-12.83	<.0001
β_{Sub41}	-0.40053	0.02974	-13.47	<.0001

β_{Sub42}	-0.03195	0.02973	-1.07	0.2826
β_{Sub43}	-0.26181	0.02973	-8.81	<.0001
β_{Sub44}	-0.52629	0.02973	-17.70	<.0001
β_{Sub45}	-0.37717	0.02973	-12.69	<.0001
β_{Sub46}	-0.15307	0.02992	-5.12	<.0001
β_{Sub47}	-0.35972	0.02984	-12.05	<.0001
β_{Sub48}	-0.52536	0.02973	-17.67	<.0001
β_{Sub49}	-0.36149	0.02979	-12.13	<.0001
β_{Sub50}	-0.29675	0.02975	-9.97	<.0001
β_{Sub51}	-0.19177	0.02973	-6.45	<.0001
β_{Sub52}	-0.32640	0.02974	-10.98	<.0001
β_{Sub53}	-0.24212	0.02973	-8.14	<.0001
β_{Sub54}	-0.43681	0.02974	-14.69	<.0001
β_{Sub55}	-0.42566	0.02975	-14.31	<.0001
β_{Sub56}	-0.31313	0.02977	-10.52	<.0001
β_{Sub57}	-0.16086	0.02973	-5.41	<.0001
β_{Sub58}	-0.01848	0.02973	-0.62	0.5342
β_{Sub59}	-0.44831	0.02974	-15.07	<.0001
β_{Sub60}	-0.05462	0.02977	-1.83	0.0666
β_{Sub61}	-0.06947	0.02974	-2.34	0.0196
β_{Sub62}	0.01420	0.02973	0.48	0.6329
β_{Sub63}	-0.47403	0.02973	-15.94	<.0001
β_{Sub64}	-0.30214	0.02973	-10.16	<.0001
β_{Sub65}	-0.03033	0.02974	-1.02	0.3079
β_{Sub66}	-0.20925	0.02977	-7.03	<.0001
β_{Sub67}	-0.13523	0.02973	-4.55	<.0001
β_{Sub68}	-0.33648	0.03006	-11.19	<.0001
β_{Sub69}	-0.04872	0.02973	-1.64	0.1014
β_{Sub70}	-0.20952	0.02973	-7.05	<.0001
β_{Sub71}	-0.05711	0.02984	-1.91	0.0558
β_{Sub72}	-0.37149	0.02974	-12.49	<.0001
β_{Sub73}	-0.05728	0.02973	-1.93	0.0541
β_{Sub74}	-0.08635	0.02977	-2.90	0.0037
β_{Sub75}	-0.03382	0.02973	-1.14	0.2554
β_{Sub76}	-0.27223	0.02973	-9.16	<.0001
β_{Sub77}	-0.06862	0.02974	-2.31	0.0211
β_{Sub78}	-0.03224	0.02974	-1.08	0.2784
β_{Sub79}	-0.12421	0.02992	-4.15	<.0001
β_{Sub80}	-0.50557	0.02973	-17.00	<.0001

Test	Source	d.f.	Mean Square	F-statistic, p-value
F tests for restrictions				
H_0: $\beta_{S2} = \beta_{S3} = \beta_{S4} = 0$	Numerator	3	0.08518	5.07
	Denominator	2945	0.01680	.0017
H_0: $\beta_{R2} = \beta_{R3} = \ldots = \beta_{R11} = 0$	Numerator	10	0.07332	4.37
	Denominator	2945	0.01680	<.0001
H_0: $\beta_{Sub2} = \beta_{Sub3} = \ldots = \beta_{Sub80} = 0$	Numerator	79	1.19040	70.88
	Denominator	2945	0.01680	<.0001

Table E-3. "Search Ratio" Regression Output

Source	Degrees of freedom	Sum of Squares	Mean Square	F statistic, p-value	R^2, Adjusted R^2
Analysis of Variance					
Model	94	377.10067	4.01171	29.72	0.4869
Error	2945	397.46246	0.13496	<.0001	0.4705
Corrected Total	3039	774.56313			

Root MSE	Dependent Mean	Coefficient of Variation
0.36737	1.29599	28.34678

Parameter	Estimated coefficient	Standard Error	t-statistic	p-value
β_0	1.29131	0.06383	20.23	<.0001
β_F	-1.28863	0.04004	-32.19	<.0001
β_T	-1.47913	0.07812	-18.93	<.0001
β_{S2}	-0.04566	0.02016	-2.27	0.0236
β_{S3}	-0.03217	0.01923	-1.67	0.0945
β_{S4}	-0.04096	0.01927	-2.13	0.0336
β_{R2}	0.07200	0.02906	2.48	0.0133
β_{R3}	0.05952	0.02905	2.05	0.0405
β_{R4}	0.05967	0.02905	2.05	0.0400
β_{R5}	0.05248	0.02905	1.81	0.0709
β_{R6}	0.00374	0.02905	0.13	0.8976

β_{R7}	0.03586	0.02906	1.23	0.2172
β_{R8}	0.04768	0.02905	1.64	0.1008
β_{R9}	0.04962	0.03165	1.57	0.1171
β_{R10}	-0.05033	0.03626	-1.39	0.1653
β_{R11}	0.05949	0.04736	1.26	0.2092
β_{Sub2}	0.01130	0.08431	0.13	0.8934
β_{Sub3}	0.12236	0.08428	1.45	0.1467
β_{Sub4}	-0.29905	0.08428	-3.55	0.0004
β_{Sub5}	0.25297	0.08429	3.00	0.0027
β_{Sub6}	0.03876	0.08428	0.46	0.6456
β_{Sub7}	0.04571	0.08428	0.54	0.5876
β_{Sub8}	0.64274	0.08431	7.62	<.0001
β_{Sub9}	-0.11023	0.08473	-1.30	0.1934
β_{Sub10}	0.03397	0.08428	0.40	0.6869
β_{Sub11}	0.24727	0.08428	2.93	0.0034
β_{Sub12}	0.31818	0.08428	3.78	0.0002
β_{Sub13}	0.21618	0.08431	2.56	0.0104
β_{Sub14}	0.06169	0.08428	0.73	0.4643
β_{Sub15}	-0.02679	0.08428	-0.32	0.7506
β_{Sub16}	0.41792	0.08437	4.95	<.0001
β_{Sub17}	0.05781	0.08428	0.69	0.4928
β_{Sub18}	0.02602	0.08428	0.31	0.7575
β_{Sub19}	0.00352	0.08428	0.04	0.9667
β_{Sub20}	0.15734	0.08431	1.87	0.0621
β_{Sub21}	0.10840	0.08429	1.29	0.1985
β_{Sub22}	0.21687	0.08428	2.57	0.0101
β_{Sub23}	-0.07578	0.08428	-0.90	0.3686
β_{Sub24}	0.89070	0.08438	10.56	<.0001
β_{Sub25}	-0.29466	0.08428	-3.50	0.0005
β_{Sub26}	-0.13298	0.08431	-1.58	0.1148
β_{Sub27}	-0.05430	0.08428	-0.64	0.5194
β_{Sub28}	0.10951	0.08428	1.30	0.1939
β_{Sub29}	-0.01683	0.08428	-0.20	0.8417
β_{Sub30}	0.07327	0.08431	0.87	0.3849
β_{Sub31}	-0.05504	0.08428	-0.65	0.5137
β_{Sub32}	-0.00689	0.08428	-0.08	0.9348
β_{Sub33}	-0.04206	0.08428	-0.50	0.6178
β_{Sub34}	-0.13633	0.08428	-1.62	0.1059
β_{Sub35}	-0.05842	0.08428	-0.69	0.4883
β_{Sub36}	-0.23829	0.08470	-2.81	0.0049
β_{Sub37}	-0.12220	0.08429	-1.45	0.1472

β_{Sub38}	-0.12339	0.08507	-1.45	0.1470
β_{Sub39}	-0.19872	0.08431	-2.36	0.0185
β_{Sub40}	-0.02286	0.08437	-0.27	0.7864
β_{Sub41}	-0.28386	0.08431	-3.37	0.0008
β_{Sub42}	-0.03509	0.08428	-0.42	0.6772
β_{Sub43}	0.28091	0.08429	3.33	0.0009
β_{Sub44}	0.32113	0.08428	3.81	0.0001
β_{Sub45}	0.04700	0.08428	0.56	0.5771
β_{Sub46}	-0.00923	0.08481	-0.11	0.9133
β_{Sub47}	0.11815	0.08460	1.40	0.1626
β_{Sub48}	0.55020	0.08428	6.53	<.0001
β_{Sub49}	-0.21941	0.08445	-2.60	0.0094
β_{Sub50}	-0.02134	0.08434	-0.25	0.8002
β_{Sub51}	0.43853	0.08428	5.20	<.0001
β_{Sub52}	0.19041	0.08431	2.26	0.0240
β_{Sub53}	0.14544	0.08428	1.73	0.0845
β_{Sub54}	0.25449	0.08431	3.02	0.0026
β_{Sub55}	0.16164	0.08433	1.92	0.0554
β_{Sub56}	-0.20344	0.08439	-2.41	0.0160
β_{Sub57}	0.13168	0.08428	1.56	0.1183
β_{Sub58}	-0.23638	0.08428	-2.80	0.0051
β_{Sub59}	0.11707	0.08431	1.39	0.1651
β_{Sub60}	-0.07769	0.08439	-0.92	0.3573
β_{Sub61}	0.06869	0.08431	0.81	0.4153
β_{Sub62}	-0.10931	0.08428	-1.30	0.1947
β_{Sub63}	0.19218	0.08428	2.28	0.0227
β_{Sub64}	0.04537	0.08428	0.54	0.5904
β_{Sub65}	-0.06985	0.08431	-0.83	0.4074
β_{Sub66}	-0.14807	0.08438	-1.75	0.0794
β_{Sub67}	-0.01817	0.08428	-0.22	0.8293
β_{Sub68}	0.37324	0.08522	4.38	<.0001
β_{Sub69}	-0.16954	0.08428	-2.01	0.0444
β_{Sub70}	-0.18176	0.08428	-2.16	0.0311
β_{Sub71}	-0.13713	0.08460	-1.62	0.1052
β_{Sub72}	-0.13674	0.08431	-1.62	0.1049
β_{Sub73}	-0.08734	0.08428	-1.04	0.3001
β_{Sub74}	0.31555	0.08438	3.74	0.0002
β_{Sub75}	0.20048	0.08428	2.38	0.0174
β_{Sub76}	-0.13044	0.08428	-1.55	0.1218
β_{Sub77}	0.19852	0.08431	2.35	0.0186
β_{Sub78}	0.05173	0.08431	0.61	0.5395

β_{Sub79}	-0.18193	0.08481	-2.15	0.0320
β_{Sub80}	0.49569	0.08428	5.88	<.0001

F tests for restrictions

Test	Source	d.f.	Mean Square	F-statistic, p-value
H_0: $\beta_{S2} = \beta_{S3} = \beta_{S4} = 0$	Numerator	3	0.29544	2.19
	Denominator	2945	0.13496	.0873
H_0: $\beta_{R2} = \beta_{R3} = \ldots = \beta_{R11} = 0$	Numerator	10	0.28732	2.13
	Denominator	2945	0. 13496	0.0195
H_0: $\beta_{Sub2} = \beta_{Sub3} = \ldots = \beta_{Sub80} = 0$	Numerator	79	1.83400	13.59
	Denominator	2945	0.13496	<.0001

Appendix F
Ex Post Subject Heuristics

Ex Post Subject Heuristics

Table Key.

Columns under "No. of Cells Chosen" heading are as follows: "$\leq$ 3" indicates the number of rounds in the given session in which the subject chooses three or fewer cells, "4 or 5" indicates the number of rounds where he/she chooses four or five cells, and "$\geq$ 6" indicates the number of rounds in which he/she chooses six or more cells.

Columns under "fixed" and "time" headings indicate the number of rounds in the given session where, respectively, the subject chooses the fixed payoff option or time expires before he/she makes a final decision.

Heuristic labels correspond to the definitions given in the text.

		No. of Cells Chosen						
Subject		$\leq$ 3	4 or 5	$\geq$ 6	fixed	time	Heuristic	Overall
1	S1	0	0	9			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	
Subject		$\leq$ 3	4 or 5	$\geq$ 6	fixed	time	Heuristic	Overall
2	S1	0	1	7		1	Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	
Subject		$\leq$ 3	4 or 5	$\geq$ 6	fixed	time	Heuristic	Overall
3	S1	0	0	9			Low	Mixed
	S2	0	1	7			Low	
	S3	4	5	1			Med	
	S4	0	1	10			Low	
Subject		$\leq$ 3	4 or 5	$\geq$ 6	fixed	time	Heuristic	Overall
4	S1	9	0	0			High	Mixed
	S2	7	1	0			High	
	S3	0	9	1			Med	
	S4	7	4	0			High	
Subject		$\leq$ 3	4 or 5	$\geq$ 6	fixed	time	Heuristic	Overall
5	S1	1	7	1			Med	Med
	S2	2	5	1			Med	
	S3	1	5	4			Med	
	S4	4	6	0	1		Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
6	S1	0	0	9			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
7	S1	2	0	7			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
8	S1	0	3	6			Low	Mixed
	S2	1	4	3			Med	
	S3	2	4	4			Med	
	S4	4	3	3		1	High	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
9	S1	0	0	1	8		Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
10	S1	0	5	4			Med	Mixed
	S2	0	1	7			Low	
	S3	2	7	1			Med	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
11	S1	0	2	7			Low	Low
	S2	0	0	8			Low	
	S3	0	1	9			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
12	S1	0	1	8			Low	Low
	S2	0	2	6			Low	
	S3	0	1	9			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
13	S1	0	2	7			Low	Low
	S2	0	1	7			Low	
	S3	0	1	8		1	Low	
	S4	0	2	9			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
14	S1	0	0	9			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
15	S1	0	0	9			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
16	S1	4	4	0	1		Med	Mixed
	S2	5	1	0	2		High	
	S3	7	2	0		1	High	
	S4	7	4	0			High	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
17	S1	0	0	9			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
18	S1	0	1	8			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
19	S1	0	0	9			Low	Low
	S2	0	0	8			Low	
	S3	0	5	5			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
20	S1	1	0	8			Low	Mixed
	S2	6	0	0	2		High	
	S3	6	4	0			High	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
21	S1	0	1	8			Low	Low
	S2	0	2	5	1		Low	
	S3	0	2	8			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
22	S1	0	6	3			Med	Med
	S2	0	7	1			Med	
	S3	0	9	1			Med	
	S4	0	6	5			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
23	S1	0	0	9			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
24	S1	9	0	0			High	Mixed
	S2	2	4	1		1	Med	
	S3	10	0	0			High	
	S4	2	8	0		1	Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
25	S1	0	0	9			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
26	S1	0	0	8		1	Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
27	S1	0	0	9			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
28	S1	0	3	6			Low	Low
	S2	0	0	8			Low	
	S3	0	1	9			Low	
	S4	0	2	9			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
29	S1	0	1	8			Low	Low
	S2	0	2	6			Low	
	S3	0	4	6			Low	
	S4	0	2	9			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
30	S1	0	1	8			Low	Low
	S2	0	1	7			Low	
	S3	0	0	10			Low	
	S4	0	1	9		1	Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
31	S1	0	0	9			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
32	S1	1	1	7			Low	Low
	S2	0	1	7			Low	
	S3	0	0	10			Low	
	S4	0	2	9			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
33	S1	0	5	4			Med	Mixed
	S2	0	1	7			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
34	S1	0	0	9			Low	Low
	S2	0	1	7			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
35	S1	1	5	3			Med	Med
	S2	1	5	2			Med	
	S3	3	5	2			Med	
	S4	4	4	3			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
36	S1	0	0	4	5		Low	Low
	S2	0	0	6	2		Low	
	S3	0	0	10			Low	
	S4	0	0	10	1		Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
37	S1	0	0	8	1		Low	Low
	S2	0	1	7			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
38	S1	4	0	0	5		High	High
	S2	3	0	0	5		High	
	S3	7	1	1	1		High	
	S4	10	1	0			High	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
39	S1	9	0	0			High	High
	S2	8	0	0			High	
	S3	10	0	0			High	
	S4	10	0	0		1	High	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
40	S1	1	8	0			Med	Med
	S2	1	4	0	3		Med	
	S3	4	6	0			Med	
	S4	2	5	3		1	Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
41	S1	1	6	2			Med	Med
	S2	0	6	0	2		Med	
	S3	2	8	0			Med	
	S4	3	7	1			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
42	S1	0	2	7			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
43	S1	1	4	4			Med	Med
	S2	0	2	5	1		Med	
	S3	0	7	3			Med	
	S4	2	3	6			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
44	S1	6	3	0			High	High
	S2	6	2	0			High	
	S3	6	4	0			High	
	S4	6	5	0			High	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
45	S1	0	9	0			Med	Med
	S2	1	7	0			Med	
	S3	0	10	0			Med	
	S4	1	9	1			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
46	S1	0	2	4			Low	Mixed
	S2	0	2	1	3		Med	
	S3	0	1	8	5		Low	
	S4	0	1	10	1		Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
47	S1	2	5	2			Med	Med
	S2	1	0	0	7		Unable	
	S3	0	8	2			Med	
	S4	5	4	2			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
48	S1	7	1	1			High	High
	S2	5	3	0			High	
	S3	9	0	1			High	
	S4	9	2	0			High	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
49	S1	4	3	0	2		High	Mixed
	S2	0	1	4	3		Low	
	S3	6	3	1			High	
	S4	4	3	4			Unable	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
50	S1	3	1	5			Low	Mixed
	S2	0	5	0	3		Med	
	S3	3	3	4			Unable	
	S4	1	7	3			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
51	S1	0	1	8			Low	Mixed
	S2	1	4	3			Med	
	S3	0	3	7			Low	
	S4	0	5	6			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
52	S1	1	7	0		1	Med	Med
	S2	0	8	0			Med	
	S3	0	5	5			Med	
	S4	0	10	1			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
53	S1	0	3	6			Low	Mixed
	S2	0	4	4			Med	
	S3	0	6	4			Med	
	S4	0	8	3			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
54	S1	2	7	0			Med	Mixed
	S2	1	5	0		2	Med	
	S3	6	4	0			High	
	S4	3	7	1			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
55	S1	3	6	0			Med	Mixed
	S2	2	3	0		3	Med	
	S3	6	3	1			High	
	S4	4	5	2			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
56	S1	2	3	4			Med	Mixed
	S2	3	5	0	2		Med	
	S3	0	2	6	2		Low	
	S4	1	6	2			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
57	S1	0	5	4			Med	Mixed
	S2	0	3	5			Low	
	S3	1	2	7			Low	
	S4	0	2	9			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
58	S1	0	1	8			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	3	8			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
59	S1	2	6	0		1	Med	Med
	S2	2	5	1			Med	
	S3	5	4	1			Med	
	S4	3	8	0			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
60	S1	0	1	8			Low	Low
	S2	0	0	8			Low	
	S3	0	0	6	4		Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
61	S1	1	1	6		1	Low	Low
	S2	0	0	8			Low	
	S3	0	1	9			Low	
	S4	0	2	9			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
62	S1	0	0	9			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
63	S1	0	9	0			Med	Med
	S2	4	4	0			Med	
	S3	4	6	0			Med	
	S4	2	9	0			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
64	S1	3	5	1			Med	Mixed
	S2	0	3	5			Low	
	S3	1	6	3			Med	
	S4	1	6	4			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
65	S1	0	0	9			Low	Low
	S2	0	0	6	2		Low	
	S3	0	1	9			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	timc	Heuristic	Overall
66	S1	3	5	1			Med	Mixed
	S2	0	0	7		1	Low	
	S3	0	0	9		1	Low	
	S4	4	2	5			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
67	S1	0	3	6			Low	Low
	S2	0	1	7			Low	
	S3	0	2	8			Low	
	S4	0	3	8			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
68	S1	0	0	0	9		Unable	Med
	S2	1	3	2	2		Med	
	S3	1	7	1	1		Med	
	S4	2	7	2			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
69	S1	0	1	8			Low	Low
	S2	1	0	7			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
70	S1	0	4	5			Low	Mixed
	S2	0	3	5			Low	
	S3	3	6	1			Med	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
71	S1	0	0	4	5		Low	Low
	S2	0	0	6	2		Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
72	S1	1	6	2			Med	Med
	S2	1	5	0		2	Med	
	S3	0	10	0			Med	
	S4	0	10	1			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
73	S1	0	0	9			Low	Low
	S2	0	3	5			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
74	S1	0	3	6			Low	Low
	S2	0	0	6		2	Low	
	S3	0	2	8			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
75	S1	0	0	9			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
76	S1	0	4	5			Low	Mixed
	S2	0	8	0			Med	
	S3	0	3	7			Low	
	S4	0	11	0			Med	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
77	S1	0	2	7			Low	Low
	S2	0	1	7			Low	
	S3	0	0	9		1	Low	
	S4	0	1	10			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
78	S1	0	1	8			Low	Low
	S2	0	0	8			Low	
	S3	0	0	10			Low	
	S4	0	1	9		1	Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
79	S1	0	0	1	8		Unable	Low
	S2	0	3	5			Low	
	S3	0	1	8	1		Low	
	S4	0	2	9			Low	

Subject		≤ 3	4 or 5	≥ 6	fixed	time	Heuristic	Overall
80	S1	7	2	0			High	Mixed
	S2	3	5	0			High	
	S3	7	3	0			High	
	S4	5	6	0			Med	

Appendix G
Computerized Interface

Computerized Interface

Overview

Brief Description

This user guide describes graphical interfaces of the research software, the software installation, and the data storage and retrieval. The software is comprised of two graphical interfaces: the Experimenter Setup Utility and the Subject Decision Interface. These two components interact to provide a controlled environment in which to evaluate the research objectives identified in this report. The Experimenter Setup Utility allows the researcher to set the parameters and control variables for the experiments. The Subject Decision Interface presents information to the experimental subjects or teams of subjects, provides a computerized interface by which they make their decisions, and records those decisions by storing them in a computerized database.

An experiment is comprised of one or more "sessions" that each subject or team of subjects completes. The number of sessions per experiment is a parameter that is determined by the experimenter independent of the software. For each subject or team, the Subject Decision Interface is executed for each separate session. Each session is comprised of one or more "rounds." The number of rounds per session is a parameter that the experimenter enters into the Experimenter Setup Utility. In each round, the subject makes choices from a matrix while facing certain constraints. The experimenter sets the matrix and constraint parameters via the Experimenter Setup Utility.

Auxiliary Software Requirements

The software is an inter- and/or intra-net application that is executed with Microsoft Internet Explorer version 5.0 (or higher). Communication between the Subject Decision Interface and the database requires Structured Query Language (SQL) to be installed on the computer acting as the fileserver. The data are stored in a SQL-Server database which can be opened using Microsoft Access or imported into Microsoft Excel.

Text Organization

This guide is organized to describe each phase as follows:

- Experimenter Setup Utility
- Subject Decision Interface including the computerized subject instructions
- Software Installation
- Data Storage and Retrieval

Experimenter Setup Utility

Experimenter Logon and Setup

The Experimenter Setup Utility is accessed by executing the file ONREXP.ASP with Internet Explorer 5.0 (or higher). (See the installation instructions below for the site and subdirectory where ONREXP.ASP is located). Upon successful execution, the login display shown in Figure G-1 appears. The user provides a valid Experimenter ID number and password. (Experimenter information is managed with some of the Procession Options described below.) Upon first-time use, a valid experimenter ID and password are provided by the software programmer.

Upon successful login, the user is taken to the Processing Options menu shown in Figure G-2. Each option is a hyperlink. The user clicks on one of the options to go to the corresponding management display. Clicking the "End Processing" button at the bottom of the display causes the user to exit the Experimenter Setup Utility

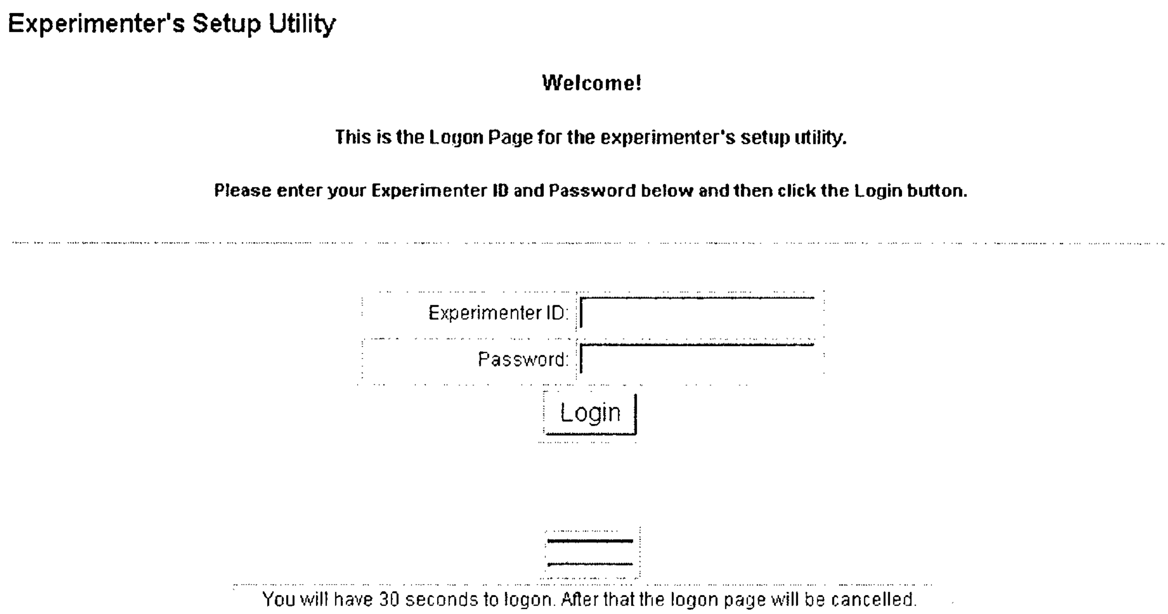


Figure G-1. Experimenter's Login Page for Experimenter Setup Utility

Experimenter's Setup Menu

Menu Options for: Tanja Blackstone

Processing Options

1. Setup a New Experimenter's Information
2. Edit an Existing Experimenter's Information
3. Delete an Existing Experimenter's Information

4. Setup a New Experimental Session
5. Edit an Existing Experimental Session
6. Clone an existing session and all related setup data
7. Edit a Round for an Existing Experimental Session
8. Add a New Round to an Existing Experimental Session
9. Delete an Existing Experimental Session
10. Delete a Round for an Existing Experimental Session

11. Setup a New Subject's Information
12. Edit an Existing Subject's Information
13. Delete an Existing Subject's Information

Reporting Options

1. Report Subjects Payment Information

End Processing

Figure G-2 Procession Options Display in Experimenter Setup Utility

Managing Experimenter Information

This subsection describes the use of Processing Options #1, #2, and #3.

Set Up Experimenter. Processing Option #1 allows the user to create a new experimenter in the database. Upon clicking the hyperlink, the user is taken to the display shown in Figure G-3. The user provides the name and password. After entry into (at least the required) fields, the user clicks the "Add to the Database" button. This adds the information to the database, and returns the user to the Procession Options menu.

Setup New Experimenter

Enter the requested data in the fields below and then click on the Add to Database button below.

First Name:	*Required Field
Initial:	
Last Name:	*Required Field
Password:	*Required Field
Confirm Password:	*Required (re-enter password to confirm it)

Add to Database

Figure G-3. Display for Procession Option #1: Setup a New Experimenter's Information

Edit Experimenter Information. Processing Option #2 allows the user to edit information on a previously existing experimenter. Upon clicking hyperlink, the user is taken to the display shown in Figure G-4. First, the user chooses an existing experimenter by clicking on the hyperlinked ID number and name (Figure G-4 (a)). The resulting display allows the user to change some or all of the entries (Figure G-4 (b)). Upon completion, the user clicks the "Commit to the Database" button. This changes the information in the database and returns the user to the Procession Options menu.

Experimenter's Setup Utility

Edit Existing Experimenter Page

The list below contains all the experimenters defined for the experiment.

Click on the experimenter's hyperlink to proceed to a page where you can edit the experimenter's information.

- ID# 1 Steve E Wells
- ID# 3 Lisa R Rutstrom
- ID# 5 Tanja Blackstone

Figure G-1(a) Choice of Hyperlinked Experimenter ID and Name via Processing Option #2

Edit Experimenter

Change the data shown in the fields below and then click on the Commit to Database button below.

First Name:	Tanja	*Required
Initial:		
Last Name:	Blackstone	*Required
Password:	****	*Required
Confirm Password:	****	*Required (re-enter the password to confirm it)

Commit to Database

Figure G-4(b) Editable Experimenter Information via Processing Option #2

Delete Experimenter Information. Processing Option #3 allows the user to delete a previously existing experimenter from the database. Upon clicking hyperlink, the user is taken to the display shown in Figure G-5. First, the user chooses an existing experimenter by clicking on the hyperlinked ID number and name (Figure G-5(a)). The resulting display shows the information about the existing experimenter and provides warnings that once the entry is deleted it is permanently lost. Upon making the decision, the user clicks the "Delete from the Database" button. THIS DECISION CANNOT BE REVERSED ONCE THIS BUTTION IS CLICKED. This deletes the information from the database and returns the user to the Procession Options menu.

Experimenter's Setup Utility

Delete Existing Experimenter Page

The list below contains all the experimenters defined for the experiment.

Click on the experimenter's hyperlink to proceed to a page where you can delete the experimenter's information.

- ID# 1 Steve E Wells
- ID# 3 Lisa R Rutstrom
- ID# 5 Tanja Blackstone

Figure G-2(a) Choice of Hyperlinked Experimenter ID and Name via Processing Option #3

Delete Experimenter

Make sure you want to delete the information below then click the Delete from Database button below.

Once you click the Delete from Database button the information cannot be recovered.

Click the BACK button on your browser if you don't want to proceed.

First Name:	Tanja
Initial:	
Last Name:	Blackstone
Password:	****

Delete from Database

Figure G-5(b) Delete-able Experimenter Information via Processing Option #3

Managing Experimental Sessions

This subsection describes the use of Processing Options #4, #5, #6, #7, #8, and #9. These options are used for the creation, editing, or deletion of sessions and rounds. Given the parameters entered by the user, the Experimenter Setup Utility automatically creates information that is used by the Subject Decision Interface.

Set Up Experimental Session. Processing Option #4 allows the user to create a new session. This involves setting a number of "global" session parameters that will apply to all rounds in the new session. After completing the global parameters, the user then sets the parameters for each of the rounds he/she wishes to add to the session. For each round, the Experimenter Setup Utility automatically creates the matrix that is used in the subject's decision-making task. The user reviews this matrix, and has the option of making changes to it before committing it to the database.

Upon clicking the hyperlink for Option #4, the user is taken to the "Set Up New Session" display shown in Figure G-6. This is where the user sets the global session parameters. After entering data in the fields, the user clicks the "Add to the Database" button. This takes the user to

the "Set Up New Round" display shown in Figure G-7, where he/she sets the parameters that apply to that individual round. After making entries, the user clicks the "Add to the Database" button. This takes the user to the matrix review display shown in Figure G-8.

Setup New Session

Enter the requested data in the fields below and then click on the Add to Database button below.

Once you do so, you will be taken to a page where you can define rounds for the session:

Experiment Name: *Required field

Experiment Password: *Required field

Password Confirmation: *Required - re-enter the password to confirm your entry

Experimenter ID #: *Required - Enter the ID # of an experimenter from the list below

Practice Session?: *Enter Y to indicate a practice session or N to indicate actual session.

Initial Payoff Amt.: *Required field - enter the value for the initial payoff

Home URL: *Required - this is the URL that the experimental subjects should be re-directed to upon experiment end.

Payoff Adjustment: *Required - this is the amount that will be deducted from experimental earnings upon experiment end.

Multi-Player Mode: 0 *Required 0 = individual play, 1 = random, 2 = dictator, 3 = vote

Total Subjects: *Required - number of subjects per session - must be an even multiple of subjects per team unless individual play

Subjects per Team: *Required - number of subjects per team unless individual play

Add to Database

List of Available Experimenters:

- ID# 1 Steve E Wells
- ID# 3 Lisa R Rutstrom
- ID# 5 Tanja Blackstone

Figure G-3 Display for Setting Global Session Parameters via Processing Option #4

Setup New Round Session #: 66 mvbtest1

Enter the requested data in the fields below and then click on the Add to Database button below. Once you do so, you will be taken to a page that displays the game matrix for this round:

Round #	1 *Required - you should number the rounds sequentially
# Rows in Matrix for Round	4 *Required - must be in the range of 2 thru 15
# Columns in Matrix for Round	4 *Required - must be in the range of 2 thru 10
Conversion Rate for Round	.025 *Required
Seconds to Allow for Playing Round	180 *Required - the number of seconds to allow in the round
Fixed Payoff for Round	120 *Required
Lower Bound for Numbers in Matrix	100 *Required - must be in range of 1 to 999999999
Upper Bound for Numbers in Matrix	250 *Required - must be in the range of 1 to 999999999 and allow for enough numbers between lower and upper bound to populate the matrix
Proportion of Positive Numbers in Matrix	100 *Required percentage of positive numbers in matrix as an integer in the range of 1 thru 100.
Seed to Use in Random # Generation	1 If you do not supply a numeric seed value a system generated seed will be used.
Value Limit	530 *Required
Cell Payoff	2 *Required Experimental $$ from a selected cell = Cell Payoff + (Cell Value Weight x Cell Value)
Cell Value Weight	4 *Required
Allow Subject to Search Options	N *Required - Y will allow subject to search options N will disallow search
Make Moves Irrevocable	Y *Required - N will allow a subject to undo moves while Y will make moves irrevocable

Add to Database | Finished Adding

Figure G-7. Display for Setting Round Specific Parameters via Processing Option #4

The matrix review display (Figure G-8) shows the subject decision matrix that the Experimenter Setup Utility automatically creates, given the parameters entered by the user in the "Set Up New Round" display (Figure G-7). Note that at the top of the display, information is shown about the round parameters that the user has selected for the round. The matrix that is shown is the subject decision matrix automatically chosen by the Experimenter Setup Utility. The individual entries in each cell of the matrix are hyperlinked. The individual matrix entries that are part of the optimal solution are shaded (on a color computer screen, they are displayed in red). See the Technical Description of Software in main body of this report for a discussion of the optimal solution algorithms.

If, because of a particular experimental design, the user wishes to modify the subject decision matrix, he/she has two options. One, the user can click the "Edit Round" button below the matrix. This takes the user back to the "Set Up New Round" display that was originally used for that round. The user can change some or all of the round parameters and then click "Add to the Database" button. The Experimenter Setup Utility then automatically chooses a new matrix, and the user is taken to the matrix review display. He/she can then review this new matrix. This process of revising the round parameters can be repeated as many times as the user deems necessary.

Second, the user can click on one of the individual hyperlinked cell entries of the matrix. This takes the user to the "Matrix Change Page" display shown in Figure G-9. Here the user can change the individual entry, subject to the round parameters he/she entered at the "Setup New Round" display (Figure G-7). Note that information about these constraints are shown on the "Matrix Change Page" display. Once the user enters a new value and then clicks the "Submit" button, the Experimenter Setup Utility automatically recalculates the optimal solution and the user is returned to the matrix review display (Figure G-8). This process of revising individual cell entries can be repeated as many times as the user deems necessary.

Once the user is satisfied with the matrix and its solution, he/she clicks the "Finished Reviewing Round Sample" button. This adds the round information to the database, and takes the user back to the "Set Up a New Round" display where he/she makes entries for another new round. For this new round, the user goes through the same process of entering round parameters and then reviewing/editing the subject decision matrix. This process of adding rounds can be repeated as many times as the user deems necessary. Once the user is finished adding new rounds, he/she clicks the "Finished Reviewing Round Sample" on the matrix display of the final round added, and then, upon returning to the "Set Up a New Round" display, clicks the "Finished Adding" button. This returns the user to the Processing Options menu.

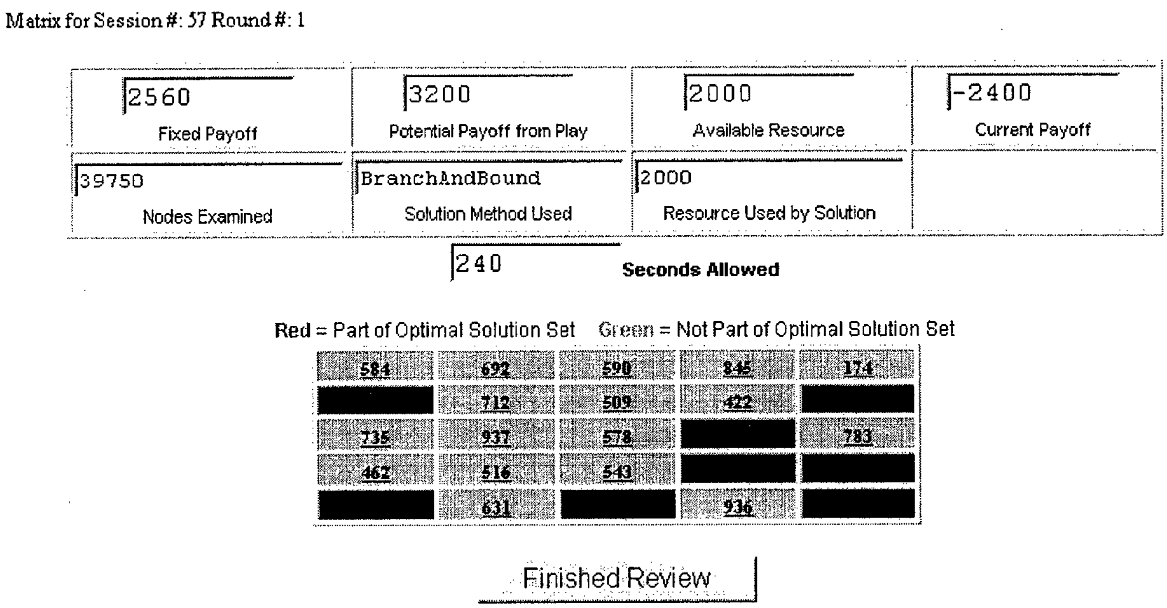


Figure G-8 Display for Reviewing and Editing the Subject Decision Matrix via Processing Option #4

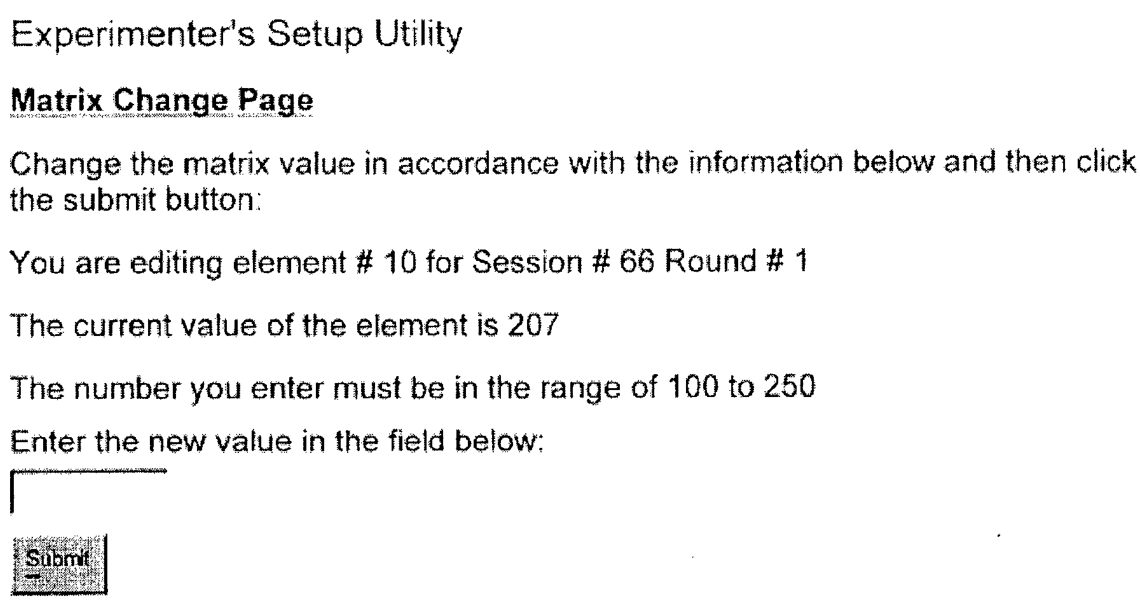


Figure G-9. Display for Editing Individual Matrix Entries via Processing Option #4

Edit Existing Sessions and/or Rounds. Processing Option #5 allows the user to edit the parameters of an existing session. Upon clicking the hyperlink, the user is taken to the screen displays shown in Figure G-10. First, the user chooses an existing session by clicking on the hyperlinked session ID number and name (Figure G-10 (a)). The resulting display allows the user to change some or all of the session parameters (Figure G-10 (b)). Notice that this display is

virtually identical to that shown in Figure G-7. Upon completion, the user clicks the "Commit to the Database" button. This changes the information in the database and returns the user to the Procession Options menu.

Experimenter's Setup Utility

Edit Existing Session

Click on the hyperlink below for the session you wish to edit.

When you do, you will be taken to a page where you can edit the information for the session selected.

- ID# 7 Test session 1
- ID# 32 Train1 2/19/01
- ID# 34 Train2 2/19/01
- ID# 54 Train3 3/10/01
- ID# 55 Train4 3/10/01
- ID# 56 Team2a 3/10/01
- ID# 57 Team2b 3/10/01
- ID# 58 Team3a 3/10/01
- ID# 59 Team3b 3/10/01

Figure G-10(a) Choice of Hyperlinked Session ID and Name via Processing Option 5

Edit an Existing Session

Enter the requested data in the fields below and then click on the Add to Database button below.

Experiment Name:	Train1 2/19/01	*Required field
Experiment Password:	****	*Required field
Password Confirmation:	****	*Required - re-enter the password to confirm your entry
Experimenter ID #:	5	*Required - Enter the ID # of an experimenter from the list below.
Practice Session?:	F	*Enter Y to indicate a practice session or N to indicate actual session.
Initial Payoff Amt.:	0	*Required field - enter the value for the initial payoff.
Home URL:	www.onr.navy.mil	*Required
Payoff Adjustment:	-10	*Optional
Multi-Player Mode:	0	*Required 0 = individual play, 1 = random, 2 = dictator, 3 = vote
Total Subjects:	1	*Required - number of subjects per session - must be an even multiple of subjects per team unless individual play
Subjects per Team:	1	*Required - number of subjects per team unless individual play

Commit to Database

List of Available Experimenters:

- ID# 1 Steve E Wells
- ID# 3 Lisa R Rutstrom
- ID# 5 Tanja Blackstone

Figure G-10(b) Display for Editing Global Session Parameters via Procession Option #5

Processing Option #6 allows the user to clone (or copy) an entire session. This is useful if a user wishes to create a new session that is similar to a previously existing session without entering all the parameters "from scratch." Upon clicking the hyperlink, the user is taken to the screen display shown in Figure G-11. The user enters the ID number from an existing session (Processing Option #5 can be used to see a list of all session names and ID numbers). After clicking the "Procced" button, the user is returned to the Processing Options menu. A new session has been created exactly like the previously existing session except that the new session has a new ID number. Thus user can then use Processing Option #5 to edit the session parameters (including the session name), and Procession Options #7, #8, or #10 (see below) to edit the round parameters, add a round with new parameters, or delete a round.

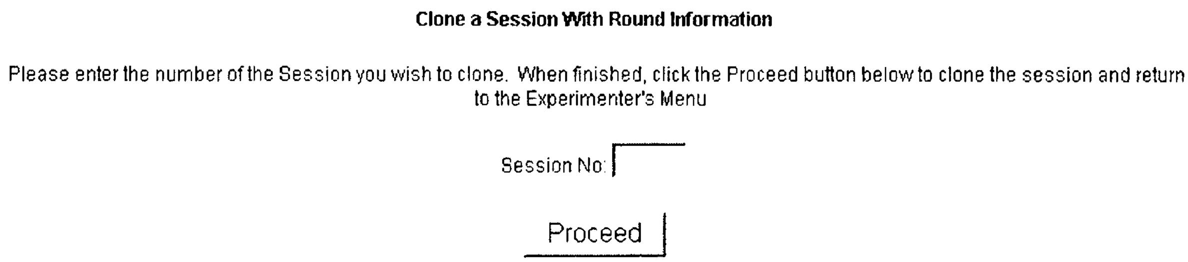


Figure G-11 Display for Processing Option #6: Clone An Existing Session and All Related Setup Data

Processing Option #7 allows the user to edit the parameter of a round or rounds in an existing session. Upon clicking the hyperlink, the user is taken to the screen displays shown in Figure G-12. First, the user chooses an existing session by clicking on the hyperlinked session ID number and name (Figure G-12(a)). This takes the user to a menu of the existing rounds for that session. Displayed with each round number is the size of the corresponding subject decision matrix (Figure G-12(b)). The user clicks on one of the hyperlinked rounds, and the resulting display allows the user to change some or all of the round parameters (Figure G-12(c)); notice that this display is virtually identical to that shown in Figure G-6. Upon completion, the user clicks the "Commit to the Database" button. This changes the round parameters in the database, and then takes to user to a matrix review display (Figure G-12(d)); notice that display is virtually identical to Figure G-8. If the user wishes to change any of the individual cell entries, he/she clicks on the individual hyperlinked cell entry, and goes to the "Matrix Change Page" shown above in Figure G-9. Once the user is finished editing any individual cell entries, he/she clicks the "Finished Review" button. This returns the user to the Processing Options menu.

Experimenter's Setup Utility

Edit Existing Round for a Session

Click on the hyperlink below for the session that owns the round you wish to edit.

- ID# 7 Test session 1
- ID# 32 Train1 2/19/01
- ID# 34 Train2 2/19/01
- ID# 54 Train3 3/10/01
- ID# 55 Train4 3/10/01
- ID# 56 Team2a 3/10/01
- ID# 57 Team2b 3/10/01
- ID# 58 Team3a 3/10/01
- ID# 59 Team3b 3/10/01

Figure G-12(a) Choice of Hyperlinked Session ID and Name via Processing Option #7

Experimenter's Setup Utility

Select Existing Round to Edit

Click on the hyperlink below for the round you wish to edit.

- Round #: 1 with 5 Rows and 5 Columns
- Round #: 2 with 5 Rows and 5 Columns
- Round #: 3 with 5 Rows and 5 Columns
- Round #: 4 with 5 Rows and 5 Columns
- Round #: 5 with 5 Rows and 5 Columns

Figure G-12(b) Choice of Hyperlinked Round Number via Processing Option #7

Edit Round # 1 For Session # 32 Train1 2/19/01

Edit the data in the fields below and then click on the Commit to Database button. Once you do so you will be taken to a screen that displays the game matrix for this round.

# Rows in Matrix for Round:	5	*Required - must be in the range of 2 thru 15
# Columns in Matrix for Round:	5	*Required - must be in the range of 2 thru 10
Conversion Rate for Round:	0.001	*Required
Seconds to Allow for Playing Round:	240	*Required - the number of seconds to allow in the round
Fixed Payoff for Round:	1000	*Required
Lower Bound for Numbers in Matrix:	100	*Required - must be in range of 1 to 999999999
Upper Bound for Numbers in Matrix:	500	*Required - must be in the range of 1 to 999999999 and allow for enough numbers between lower and upper bound to populate the matrix
Proportion of Positive Numbers in Matrix:	100	*Required - percentage of positive numbers in matrix as an integer in the range of 1 to 100
Seed to Use in Random # Generation:	0	If you do not supply a numeric seed then a system generate seed will be used.
Value Limit:	1500	*Required
Cell Payoff:	100	*Required - Experimental $$ from a selected cell = Cell Payoff + (Cell Value Weight x Cell Value)
Cell Value Weight:	1.2	*Required
Allow Subject to Search Options:	N	*Required - Y will allow subject to search options N will disallow search
Make Moves Revocable:	Y	*Required - Y will allow subject to undo moves while N will make moves irrevocable

Commit to Database

Figure G-12(c) Display for Editing Round Specific Parameters via Processing Option #7

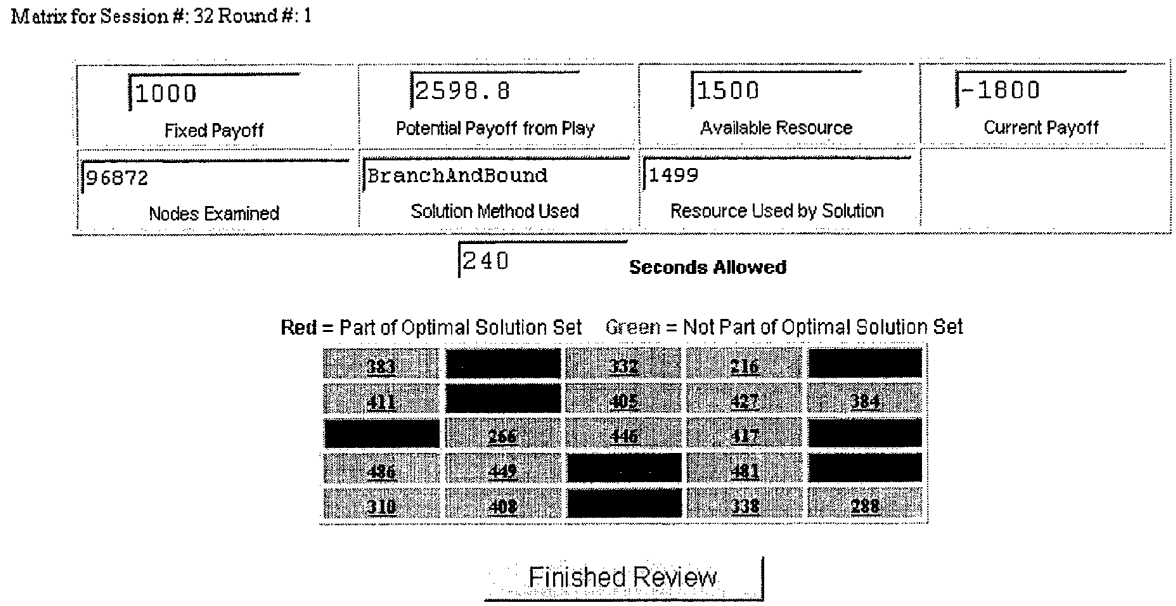


Figure G-12(d) Matrix Review Display for Reviewing and Editing Subject Decision Matrix via Processing Option #7

Processing Option #8 allows the user to add a new round or rounds in an existing session. Upon clicking the hyperlink, the user is taken to the screen displays shown in Figure G-13. First, the user chooses an existing session by clicking on the hyperlinked session ID number and name (Figure G-13 (a)). This takes the user to a display where he/she enters the parameters for the new round. After entering the parameters, the user clicks on the "Add to Database" button. This adds the round parameters to the database and takes the user to the matrix review display shown above in Figure G-8. The process for reviewing and revising the subject decision matrix is identical to that described above. Also, the process for adding multiple rounds is identical to the process of adding multiple rounds to a new session, so the reader is again referred to the preceding sections. When the user is done adding new rounds to an existing session, he/she clicks the "Finished Adding" button and returns to the Processing Options menu.

Experimenter's Setup Utility

Add a New Round to an Existing Session

Click on the hyperlink below for the session that will own the round you wish to add.

- ID# 7 Test session 1
- ID# 32 Train1 2/19/01
- ID# 34 Train2 2/19/01
- ID# 54 Train3 3/10/01
- ID# 55 Train4 3/10/01
- ID# 56 Team2a 3/10/01
- ID# 57 Team2b 3/10/01
- ID# 58 Team3a 3/10/01
- ID# 59 Team3b 3/10/01

Figure G-13(a) Choice of Hyperlinked Session ID and Name via Processing Option #8

Setup New Round Session #: 32 Train1 2/19/01

Round #:	6 *Required - you should number the rounds sequentially
# Rows in Matrix for Round:	*Required - must be in the range of 2 thru 15
# Columns in Matrix for Round:	*Required - must be in the range of 2 thru 10
Conversion Rate for Round:	*Required
Seconds to Allow for Playing Round:	*Required - the number of seconds to allow in the round
Fixed Payoff for Round:	*Required
Lower Bound for Numbers in Matrix:	*Required - must be in range of 1 to 999999999
Upper Bound for Numbers in Matrix:	*Required - must be in the range of 1 to 999999999 and allow for enough numbers between lower and upper bound to populate the matrix
Proportion of Positive Numbers in Matrix:	*Required - percentage of positive numbers in matrix as an integer in the range of 1 thru 100.
Seed to Use in Random # Generation:	If you supply a seed it must be numeric. If you do not, a system generated seed will be used.
Value Limit:	*Required
Cell Payoff:	*Required Experimental $$ from a selected cell = Cell Payoff + (Cell Value Weight x Cell Value)
Cell Value Weight:	*Required
Allow Subject to Search Options:	*Required - Y will allow subject to search options N will disallow search
Make Moves Irrevocable:	*Required - N will allow subject to undo moves while Y will make moves irrevocable

Add to Database | Finished Adding

Figure G-13(b) Display for Adding Round Specific Parameters via Processing Option #8

Delete Existing Sessions and/or Rounds. Processing Option #9 allows the user to delete an existing session from the database. Upon clicking the hyperlink, the user is taken to the screen displays shown in Figure G-14. First, the user chooses an existing session by clicking on the hyperlinked session ID number and name (Figure G-14 (a)). This takes the user to a display that shows the session parameters of the existing session and provides warnings that once the entry is deleted it is permanently lost. Upon making the decision, the user clicks the "Delete Session from the Database" button. THIS DECISION CANNOT BE REVERSED ONCE THIS BUTTION IS CLICKED. This deletes the information from the database and returns the user to the Procession Options menu.

Experimenter's Setup Utility

Delete Existing Session Page

The list below contains all the sessions defined for the experiment.

Click on the session's hyperlink to proceed to a page where you can delete the session information.

- ID# 7 Test session 1
- ID# 32 Train1 2/19/01
- ID# 34 Train2 2/19/01
- ID# 54 Train3 3/10/01
- ID# 55 Train4 3/10/01
- ID# 56 Team2a 3/10/01
- ID# 57 Team2b 3/10/01
- ID# 58 Team3a 3/10/01
- ID# 59 Team3b 3/10/01

Figure G-14(a) Choice of Hyperlinked Session ID and Name via Processing Option #9

Delete an Existing Session and All Related Rounds

Make sure you want to delete the session information shown below.

Be aware that deleting the session will also delete all rounds that you have defined for the session.

Once you delete the session the information cannot be recovered:

Experiment Name:	Train1 2/19/01
Experiment Password:	****
Experimenter ID #:	5
Practice Session?:	F
Initial Payoff Amt.:	0
Home URL:	www.onr.navy.mil
Payoff Adjustment:	
Multi-Player Mode:	0 *Required 0 = individual play, 1 = random, 2 = dictator, 3 = vote
Total Subjects:	1 *Required - number of subjects per session - must be an even multiple of subjects per team unless individual play
Subjects per Team:	1 *Required - number of subjects per team unless individual play

Delete Session from Database

Figure G-14(b) Display for Deleting a Session via Processing Option #9

Processing Option #10 allows the user to delete a round of an existing session from the database. Upon clicking the hyperlink, the user is taken to the screen displays shown in Figure G-15. First, the user chooses an existing session by clicking on the hyperlinked session ID number and name (Figure G-15 (a)). This takes the user to a menu of the existing rounds for that session. Displayed with each round number is the size of the corresponding subject decision matrix (Figure G-15 (b)). The user clicks on one of the hyperlinked rounds. This takes the user to a display that shows the parameters of the parameters (Figure G-12(c)). Upon making the decision, the user clicks the "Delete from Database" button. <u>THIS DECISION CANNOT BE EVERSED ONCE THIS BUTTION IS CLICKED</u>. This deletes the information from the database and returns the user to the Procession Options menu.

Experimenter's Setup Utility

Delete an Existing Round for a Session

Click on the hyperlink below for the session that owns the round you wish to delete.

- ID# 7 Test session 1
- ID# 32 Train1 2/19/01
- ID# 34 Train2 2/19/01
- ID# 54 Train3 3/10/01
- ID# 55 Train4 3/10/01
- ID# 56 Team2a 3/10/01
- ID# 57 Team2b 3/10/01
- ID# 58 Team3a 3/10/01
- ID# 59 Team3b 3/10/01

Figure G-15(a) Choice of Hyperlinked Session ID and Name via Processing Option #10

Experimenter's Setup Utility

Select Existing Round to Delete For Session #: 32 Train1 2/19/01

Click on the hyperlink below for the round you wish to Delete.

- Round #: 1 with 5 Rows and 5 Columns
- Round #: 2 with 5 Rows and 5 Columns
- Round #: 3 with 5 Rows and 5 Columns
- Round #: 4 with 5 Rows and 5 Columns
- Round #: 5 with 5 Rows and 5 Columns

Figure G-15(b) Choice of Hyperlinked Session ID and Name via Processing Option #10

Delete Round #1 For Session #32 Train1 2/19/01

Make sure you want to delete the information shown below and then click on the Delete from Database button. Once deleted, the data cannot be recovered. The remaining rounds will have the round number reduced by 1 to keep correct sequential order.

# Rows in Matrix for Round:	5
# Columns in Matrix for Round:	5
Conversion Rate for Round:	0.001
Seconds to Allow for Playing Round:	240
Fixed Payoff for Round:	1000
Lower Bound for Numbers in Matrix:	100
Upper Bound for Numbers in Matrix:	500
Proportion of Positive Numbers in Matrix:	100
Seed to Use in Random # Generation:	0
Value Limit:	1500
Cell Payoff:	100
Cell Value Weight:	1.2
Allow Subject to Search Options:	N
Make Moves Irrevocable:	Y

Delete from Database

Figure G-15(c) Display for Deleting a Round via Processing Option #9

Managing Subject Information

This section discusses Procession Option # 11 and Reporting Option # 1 These options provide information about subjects in the database.

Listing Subject IDs and Names. Processing Option #11 allows the user to view a list of the ID numbers and subjects' names in the database. This is useful for using the Reporting Options discussed below. Upon clicking the hyperlink, the user is taken to the screen displays shown in Figure G-16. The user can then record the information from the screen, e.g., with pen and paper or "cut and paste" options of a word processor.

Setup New Subject

Enter the requested data in the fields below and then click on the Add to Database button below.

First Name:		*Required Field
Initial:		
Last Name:		*Required Field

Add to Database

Figure G-16(a) Display for Processing Option #11: List Subject ID Numbers and Names

Experimenter's Setup Utility

Edit Existing Subject Page

The list below contains all the subjects defined for the experiment.

Click on the subject's hyperlink to proceed to a page where you can edit the subject's information.

- ID# 22 S E W
- ID# 24 Wells1
- ID# 25 wells1
- ID# 26 wells2
- ID# 27 wells3
- ID# 28 wells4
- ID# 31 wells5
- ID# 32 wells6
- ID# 41 Wells1
- ID# 42 wells2
- ID# 43 wells3
- ID# 44 wells4
- ID# 360 tanja f blackstone

Figure G-16(b) Edit an Existing Subject's Information

Edit Subject

Change the data shown in the fields below and then click on the Commit to Database button below.

First Name:	S	*Required Field
Initial:		
Last Name:	W	*Required Field

Commit to Database

Figure G-16(c)_Edit an Existing Subject's Information example

Experimenter's Setup Utility

Delete Existing Subject Page

The list below contains all the subjects defined for the experiment.

Click on the subject's hyperlink to proceed to a page where you can delete the subject's information.

- ID# 22 S E W
- ID# 24 Wells1
- ID# 25 wells1
- ID# 26 wells2
- ID# 27 wells3
- ID# 28 wells4
- ID# 31 wells5
- ID# 32 wells6
- ID# 41 Wells1
- ID# 42 wells2
- ID# 43 wells3
- ID# 44 wells4
- ID# 360 tanja f blackstone

Figure G-16(d) Delete an Existing Subject's Information

Delete Subject

Make sure you want to delete the information below then click the Delete from Database button below.

Once you click the Delete from Database button the information cannot be recovered.

Click the BACK button on your browser if you don't want to proceed.

First Name:	S
Initial:	E
Last Name:	W

Delete from Database

Figure G-16(e) Delete an Existing Subject's Information Example

Subjects Payment Information. Reporting Option #1 allows the user to view the payoff table of an individual subject in a session. The display shows a subject's per-round and aggregate earnings in the given session. Upon clicking the hyperlink, the user is taken to the screen displays shown in Figure G-17. First, the user enters the session ID number and the ID number for the given subject (Figure G-17(a)) and then clicks the "Proceed" button. This displays the subject's payoff table for the given session. This display is identical to the final screen display that the subject sees via the Subject Decision Interface. If there is no data in the database on the subject for the given round, a "no data" message is displayed (Figure G-17(c)). The user finishes viewing the payoff information, clicks the "Proceed" button, and returns to the Processing Options menu.

Subject Payments Information

Please enter the Session # and Subject # for which you wish to report payment information in the fields provided below.

Session #	
Subject #	

Click the Proceed button to continue:

Proceed

Figure G-17(a) Display for Entering the Subject's Session and Round IDs via Reporting Option # 1

Session # 57 Subject # 9801

A summary of the requested payment information is shown below. When finished, click the Proceed button below to return to the Experimenter's Menu

Proceed

Session	Round	The most you could have earned in experimental dollars	What you actually earned in experimental dollars	Conversion rate applied to round earnings to convert experimental dollars to US currency	Your earnings in US currency
57	1	12550.00	.00	.10000	$.00
57	2	13525.00	.00	1.00000	$.00
57	3	3180.00	3034.00	1.00000	$3034.00
				Standard Adjustment	**$5.00**
TOTALS		**29255.00**	**3034.00**		**$3039.00**

Figure G-17(b). Display of Subject's Earnings via Reporting Option #1

Session # 66 Subject # 6302

A summary of the requested payment information is shown below. When finished, click the Proceed button below to return to the Experimenter's Menu

Proceed

There are no records on file for this session for this subject

Figure G-17(c) Display of Message When No data on the Subject/Session Combination Exists in the Database

Subject Decision Interface

Brief Description

This section describes the graphical Subject Decision Interface. This interface presents information to the experimental subjects or teams of subjects, provides a computerized interface by which they make their decisions, and records those decisions by storing them in a computerized database. All parameters, decisions, payoffs, etc. shown in this section are for illustrative purposes only.

The Subject Decision Interface consists of four main parts: the login and subject information module, the instruction module, the decision module where subjects or teams make their decisions during the rounds of a given session, and the payoff display module.

Login Display and Subject Information

The Subject Decision Interface is accessed by executing the file ONREXP.PLAY with Internet Explorer 5.0 (or higher). (See the installation instructions below for the site and subdirectory where ONRPLAY.ASP is located). Upon successful execution, the login display shown in Figure G-18 appears. The subject enters a subject ID number and a valid session number. This information is provided externally to the subject by the experimenter, i.e., via written or verbal communication. Logging by duplicate subject ID number/Session number combinations is not permitted. However, a given subject ID number can be used in combination with multiple session numbers. Thus a given subject can complete an arbitrary number of sessions.

NOTE: The experimenter should maintain a log of assigned numbers. This will prevent unauthorized participation, which is particularly important if the experiments are to be run from remote sites. If the experimenter wants the same subject to participate in the same session multiple times, a new subject ID number must be provided each time the subject completes the session. Additionally, even if a subject's session is prematurely terminated (e.g., due to a power failure), the subject ID/session number combination is nonetheless stored in the database as long as the subject has proceeded past the login display. Thus, if the experimenter wants the subject to complete an aborted session, the subject must be logged with a different subject ID number but same session number. The experimenter should maintain a log of multiple numbers for an individual subject, so that data analysis can be adjusted accordingly.

After successfully logging on, the subject sees the screen display shown in Figure G-19. If the session is set up for individual decision-making, the subject enters information in the Player 1 boxes only. If the session is set up for team decision-making, each subject enters his/her individual information in the appropriate Player boxes. If the team consists of fewer than four members, the remaining boxes are left blank. After the appropriate information has been entered, the subject or team clicks the "Proceed" button.

After logging in and providing information, the subject or team goes through a set of computerized instructions. These instructions are shown on multiple pages of Figure G-20. The experimenter(s) may also administer non-computerized instructions as described below. The instructions are self-paced, and they describe the information and decisions that subject or team will make each round. The instructions include examples and explain all of the parameters

needed for the decision task. Once the subject or team has completed the instructions, a "Begin Play" hyperlink on the last page of the instructions provides the link to the first round of the session. If an experimenter wishes to provide non-computerized instruction, subjects may be requested to wait for external instruction before clicking "Begin Play."

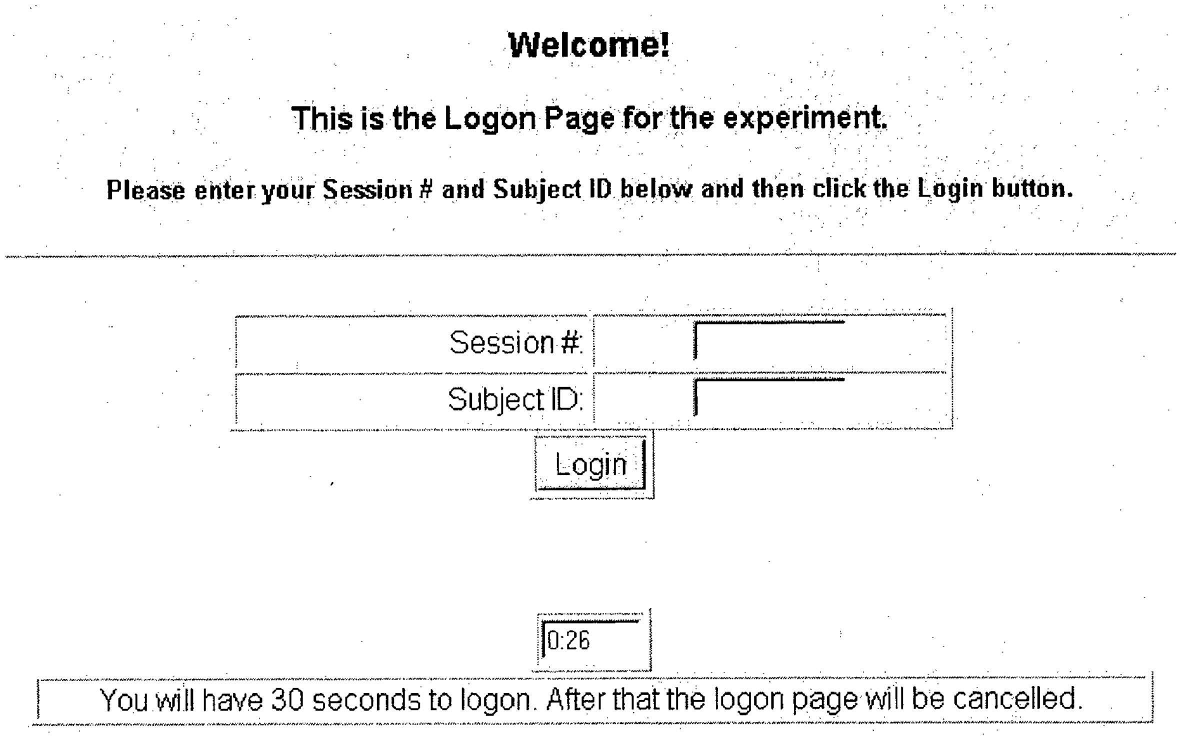


Figure G-18. Login Display for Subject Decision Interface

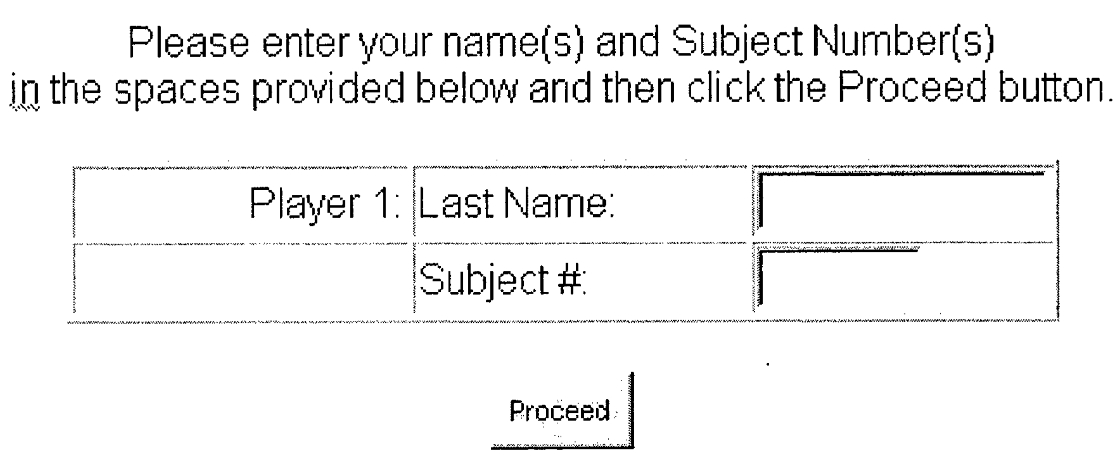


Figure G-19. Subject Information Display in the Subject Decision Interface

Experiment Instructions - Page 1

This experiment is part of a study about how people make decisions. If you follow the instructions and make your decisions carefully, you may earn a considerable amount of money that will be paid to you in cash at the end of the experiment. This research is funded by research grants, so we encourage you to make as much money as possible.

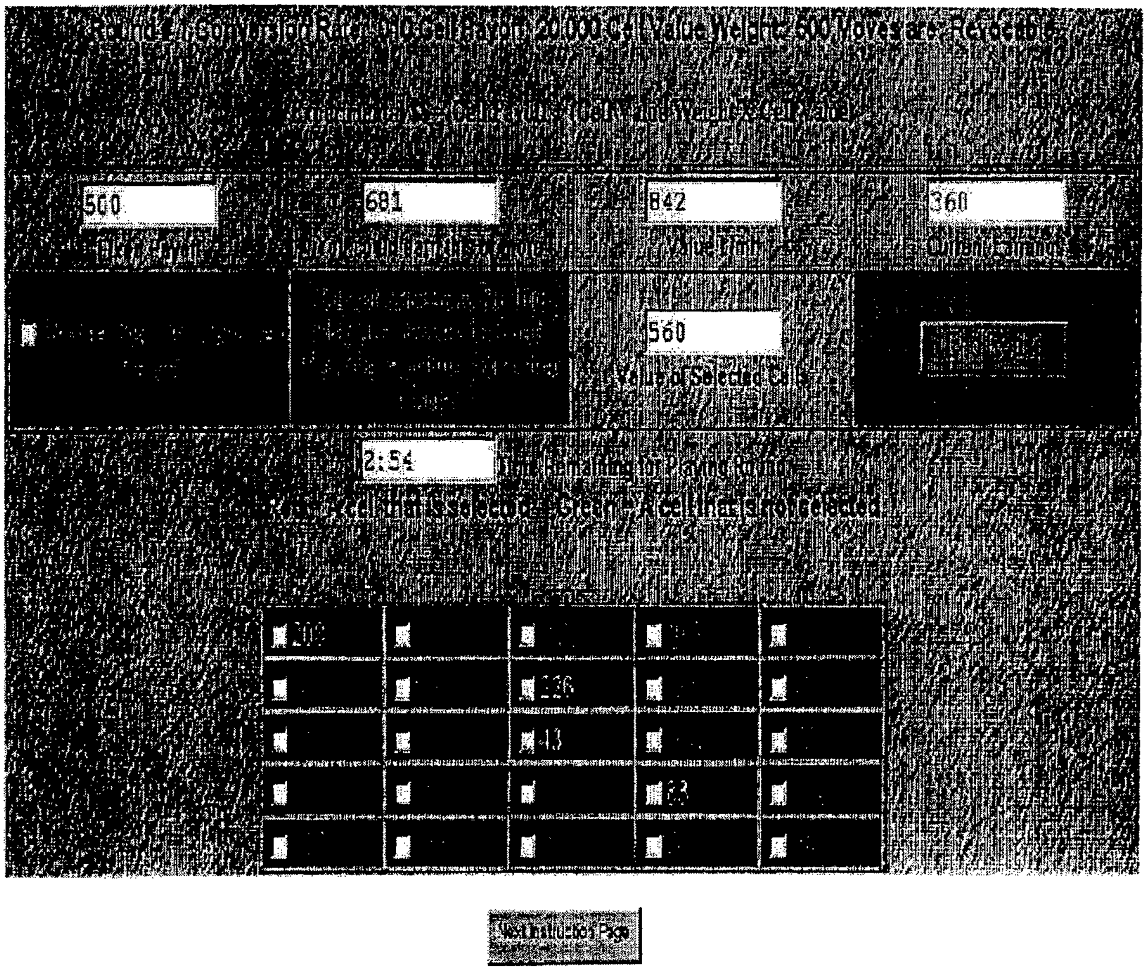
In this experiment you will make decisions in several **Rounds**. The money you earn will depend on the decisions you make. Some decisions will earn you more money than others The rules regarding your decisions and how your decisions translate into earnings will be explained in a few moments.

Below is an example of the display that you will see in each Round. The details of this display will be explained during these instructions. But any numbers or examples you see are for instructional purposes only. They are not suggestions as to what you should or should not do during the experiment. The numbers you see during the experiment could be quite different from those you see during the instructions.

Take a moment to look at the display. When you are ready to continue, click on the "Next Instruction Page" button at the bottom of the page

Note: In the computerized version, the text on this page and the graphical display on the following page are displayed on one computer screen.

Figure G-20. Computerized Instructions provided as part of Subject Decision Interface (8 pages)



Note: In the computerized version, the text on this page and the graphical display on the following page are displayed on one computer screen.

Experiment Instructions—Page 2

Experiment Instructions - Page 2

In each Round, you will be shown a **matrix**. Here is the matrix from the previous page:

208	68	164	222	72
131	44	226	160	25
139	42	43	185	80
31	82	100	83	216
222	104	79	55	55

Notice that the matrix consists of many **cells**, each with a number in it. The number displayed in each cell is called the **cell value**.

You will select cells from the matrix, according to certain rules. The cells you select will determine your earnings for the Round. To select a cell, you click the box next to the number in that particular cell.

Initially, all the cells will be green. Once a cell is selected, it will be shown in red. In the example above, four cells have been selected. The cells that have been selected have cell values of 208, 226, 43 and 83.

Click on the "Next Instruction Page" button below when you are ready to continue.

Next Instruction Page

Experiment Instructions—Page 3

Experiment Instructions - Page 3

Sometimes you may be able to "deselect" a cell. A cell that is selected and then "deselected" will be shown in green as if it had never been selected in the first place.

208	68	164	222	72
131	44	226	160	25
139	42	43	185	80
81	82	100	83	216
222	104	79	55	55

In the matrix shown above, the cell with 83 in it was selected and then deselected. Notice that the background of the cell with 83 in it reverted to green.

When you are allowed to change your selections and "deselect" cells, then **Moves are Revocable**. If you are not allowed to change your mind after selecting a cell, then **Moves are Not Revocable**.

In each Round, an "information line" at the top of the display will indicate whether moves are revocable or not. Here is the information line from the display that was shown on the first page of these instructions:

Round # 1 Conversion Rate: .010 Cell Payoff: 20.000 Cell Value Weight: .500 Moves are: Revocable

Notice that on the far left hand side of the information line, the Round number is shown. (**Round # 1** in this example). On the far right hand side, whether moves are revocable or not revocable is shown. In this example, **Moves are: Revocable**. The other information (Conversion Rate, Cell Payoff, and Cell Value Weight) will be discussed in a few moments.

Click on the "Next Instruction Page" button below when you are ready to continue.

Next Instruction Page

Experiment Instructions—Page 4

Experiment Instructions - Page 4

Your earnings from the experiment will depend on the cells you select. The information line contains information about how your selections determine your earnings. Here is the example information line again:

Round # 1 Conversion Rate: .010 Cell Payoff: 20.000 Cell Value Weight: .500 Moves are: Revocable

As mentioned earlier, the first piece of information is the Round number. The second piece of information is the Conversion Rate. During the experiment, your earnings will be shown in "experimental dollars." These experimental dollars will be turned into U.S. currency at the end of the experiment, using a conversion factor. In this example, the conversion rate is 0.010. Thus each experimental dollar is equal to $0.01 of U.S. currency.

The earnings from selecting a given cell are based on three factors: the **cell value**, the **Cell Payoff** and the **Cell Value Weight**. Recall that the cell value is the number that is displayed in each cell of the matrix. The Cell Payoff and Cell Value Weight are shown in the information line. In the example above, the Cell Payoff is 20 and the Cell Value Weight is 0.50.

Here is the formula that determines how many experimental dollars you earn for each cell that you select:

Experimental $$ from a selected cell = Cell Payoff + (Cell Value Weight X Cell Value)

In the example matrix shown earlier, one of the selected cells had a cell value of 208. If the Cell Payoff is 20 and the Cell Value Weight is 0.50, then the experimental earnings from selecting the cell with a cell value of 208 would be:

20 + (0.50 X 208) = 20 + 104 = 124 Experimental $$

Click on the "Next Instruction Page" button below when you are ready to continue.

Next Instruction Page

Experiment Instructions—Page 5

Experiment Instructions - Page 5

In addition to the matrix and information line, status and control information is also displayed for each Round. Here is an example:

500 **Fixed Payoff**	681 **You could earn this or more**	842 **Value Limit**	360 **Current Earnings**
Decline Play - Accept Fixed Payoff	You can choose to Decline Play and accept the Fixed Payoff at any time during the round.	560 **Value of Selected Cells**	End Round

Notice the two boxes labeled **Value Limit** and **Value of Selected Cells** (the third boxes from the left or second from the right in the top and bottom rows, respectively). In this example, the Value Limit is shown as 842 and the value of Selected Cells is shown as 560.

Recall that the number in each cell of the matrix is called the **cell value**. The computer automatically calculates the sum of the values from the cells that you select. This sum is called the **Value of Selected Cells**. Earlier in the instructions you were shown a matrix where the selected cells had cell values of 208, 226, 43 and 83. Thus, when the **cell value** in each of the selected cells is summed, the **Value of Selected Cells** is 208 + 226 + 43 + 83 = 560.

You may continue to select cells as long as the Value of Selected Cells does not exceed the Value Limit. In the example above, the Value of Selected Cells is less than the Value Limit (560 < 842 Thus, cells can still be selected, as long as the **cell value** of any new selections does not exceed 262. That is, the remaining distance between the Value Limit and the Value of Selected Cells is 822 - 560 = 262.

The computer will not allow you to select a cell when doing so would cause the Value of Selected Cells to exceed the Value Limit. Any time you try to make such a selection you will receive an error message from the computer.

Click on the "Next Instruction Page" button below when you are ready to continue.

Next Instruction Page

Experiment Instructions—Page 6

Experiment Instructions - Page 6

500 **Fixed Payoff**	681 **You could earn this or more**	842 **Value Limit**	360 **Current Earnings**
☐ Decline Play - Accept Fixed Payoff	You can choose to Decline Play and accept the Fixed Payoff at any time during the round.	560 **Value of Selected Cells**	End Round

The box in the upper left corner of the table above shows a **Fixed Payoff**. In each Round, you can choose whether to earn money by selecting cells or by taking the Fixed Payoff. To accept the Fixed Payoff, check the box in the lower left corner where it says "**Decline Play - Accept Fixed Payoff**." **If you click this box, the Round will end.**

In the example above, the Fixed Payoff is 500. If you clicked the Decline Play box, the Round would end and your earnings for the Round would be 500 experimental dollars.

In some instances, you might have to decide whether or not to accept the Fixed Payoff at the start of a Round. When this is the case, once you select a cell in the matrix, accepting the Fixed Payoff will no longer be an option.

In other instances, you might be able to accept the Fixed Payoff at any time during a Round. That is, after you have selected some cells you would still have the option of taking the Fixed Payoff. If this is the case, then the box to the right of the Decline Play box will show the following message:

You can choose to Decline Play and accept the Fixed Payoff at any time during the round.

This message is shown in the example above. If you must decide whether or not to accept the Fixed Payoff at the start of a Round (before making any selections), this box will display a message informing you that you have to choose before you make a cell selection. When you have to choose before making a cell selection, the Decline Play option will disappear once you make a cell selection.

Click on the "Next Instruction Page" button below when you are ready to continue.

Next Instruction Page

Experiment Instructions—Page 7

Experiment Instructions - Page 7

500 **Fixed Payoff**	681 **You could earn this or more**	842 **Value Limit**	360 **Current Earnings**
☐ Decline Play - Accept Fixed Payoff	You can choose to Decline Play and accept the Fixed Payoff at any time during the round.	560 **Value of Selected Cells**	End Round

The second box from the left (or third from the right) in the top row of the table above shows how much you might be able to earn by selecting cells. Your earnings could be this much or possibly more. In this example, you could earn 681 or possibly more experimental dollars.

The **Current Earnings** box is in the upper right hand corner. This is your earnings (in experimental dollars) from all the cells that you select. Recall that a formula is used to determine the earnings from each cell that you select based on the cell value, the Cell Payoff and the Cell Value Weight. The Current Earnings is the sum of your earnings, in experimental dollars, from all of the cells you have selected.

Once you finish selecting cells in a Round, click the **End Round** button shown in the lower right hand corner. Your earnings for the Round, in experimental dollars, will be the Current Earnings amount that is displayed at the time you click the End Round button.

Click on the "Next Instruction Page" button below when you are ready to continue.

Next Instruction Page

Experiment Instructions—Page 8

Experiment Instructions - Page 8

A timer on the screen shows how much time remains in a Round. When the timer reaches 0:00, the computer automatically ends the Round. Here is an example of the timer:

2:54 **Time Remaining for Playing Round**

In this example, 2 minutes and 54 seconds remain before the computer will automatically end the round.

A Round ends when **one** of the following things happen:

1. You choose the Decline Play option, or
2. You click the End Round button, or
3. Time expires for the Round.

If time expires and the computer ends the round before you select at least one cell or Decline Play, **you will not earn any experimental dollars** for that Round.

Your experimental earnings from participation in this experiment is the sum of your experimental earnings from all Rounds. If the experiment lasted three Rounds, and your experimental earnings were 298.5 in Round 1, 989 in Round 2, and 1286 in Round 3, your total experimental earnings would be 2573.5 Experimental $$. As mentioned earlier, these Experimental $$ would be converted into U.S. currency using the Conversion Rate specified for each Round.

Do you have any questions? If so, raise your hand and someone will assist you. If you do not understand these instructions, it may affect your ability to earn money. Please feel free to ask questions.

When you are ready to begin Round 1, click the **Begin Play** link below.

Begin Play

Subject Decision Display

The decision-making interface seen by the subject is displayed in Figure G-21. The subject moves to this display after clicking the "Begin Play" hyperlink at the end of the Subject Instructions.

Information relevant to the subject's decision is shown at the top and middle of the display. The values shown are determined by the parameters set by the experimenter via the Experimenter Setup Utility. See the section Technical Description of the Software in this report for a description of the Fixed Payoff, Value Limit, etc.

The subject makes decisions by clicking in the boxes of the subject decision matrix. The individual cells are colored in green, and when selected by the subject, the color changes to red. In Figure G-21, "green" is depicted by the lighter shading, and "red" is depicted by the darker shading. For example, in Figure G-21, the middle cell of the matrix, with a value of 284, is the only cell that has been selected.

Alternatively, the subject may choose to accept the Fixed Payoff by clicking the "Decline Play—Accept Fixed Payoff" box on the left hand side of the display. The round ends when the subject either 1) selects the Fixed Payoff, 2) clicks the "End Round" button on the right hand side of the display, or 3) the "Time Remaining for Playing Round" in the middle of the screen reaches zero.

After the end of a round, the subject is taken to the next round, with a similar display. That is, any two rounds will have identical displays except as dictated by the parameters, e.g., the matrix size, Fixed Payoff, Value Limit, etc. may be different. The experimenter, using the Experiment Setup Utility, determines the parameters for each round in advance.

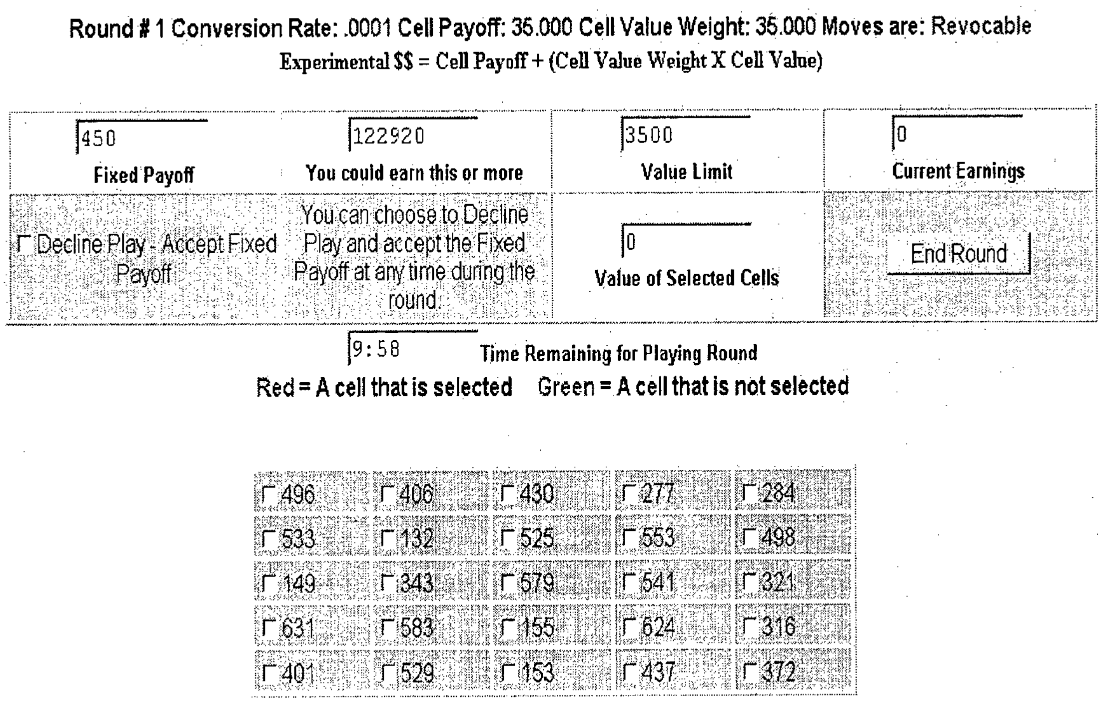


Figure G-21. Display for Subject Decision Interface

Subject Payoff Display

After the end of the final round of a session, the subject is taken to a payoff display shown in Figure G-22. The display reports both the per-round and aggregate session earnings. When the "Proceed" button is clicked , the default web page is displayed. This default page is set in the Experimenter Setup Utility.

Session # 57 Subject # 9801

A summary of your payment information is shown below.

Session	Round	The most you could have earned in experimental dollars	What you actually earned in experimental dollars	Conversion rate applied to round earnings to convert experimental dollars to US currency	Your earnings in US currency
57	1	12550.00	.00	.10000	$.00
57	2	13525.00	.00	1.00000	$.00
57	3	3180.00	3034.00	1.00000	$3034.00
				Standard Adjustment	**$5.00**
TOTALS		**29255.00**	**3034.00**		**$3039.00**

Proceed

Figure G-22. Display for Subjects' Payment Information

Software Installation

The software is installed via executable SETUP.EXE files. These setup programs can be sent via File Transfer Protocol (FTP) from the software programmer to the user's fileserver. Files will be FTPd to (path)\ONR, (path)\ONR\GAMEPLAY and (path)\ONR\ART.

The fileserver machine should have a Windows NT Server or Windows 2000 Server operating system, and have Internet Information Services (IIS) running. The instructions in the setup program are straightforward. Here are the steps for a new installation.

Experimenter Setup Utility Installation

To start the installation of the Experimenter Setup utility, locate the SETUP.EXE file in the (path)\ONR directory where it was "FTPd" and doubleclick on the icon. During the installation, the user will be prompted to provide a directory where files will be located. A suggested directory is C:\ProgramFiles\ONR. NOTE: if the operating system is WinNT, then the software should be installed on the D: partition of the hard drive. But the user is free to install the software in any directory. Use the "Change Directory" box on the appropriate display to choose, make, or otherwise select the destination directory.

If necessary, the setup program will install data access components or "dll" files, i.e., only if they do not already exist on the server or if those present are outdated. The data access components are installed when the setup program runs the standard MDAC installation program from Microsoft. This install from Microsoft automatically checks to ensure that all component versions are as required by the software, and will replace any components on the resident server only if necessary for proper functioning of the software.

After successful completion of the installation, the fileserver may or may not need to be rebooted, depending on whether the data access components required the automatic installation or updating. If the server does not need to be rebooted, the setup program will inform the user accordingly.

Subject Decision Interface Installation

After the reboot (or after the installation if a reboot was not required), the Subject Decision Interface needs to be installed. To begin this installation, locate the SETUP.EXE file in the (path) \ONR\GamePlay directory where it was "FTPd" and double-click on the icon. Notice that this is a different setup program, located in a different subdirectory. During the installation, the user will be prompted to provide a directory where files will be located. Be sure to select the SAME DIRECTORY where the Experimenter's Setup Utility was installed, e.g., D:\ProgramFiles\ONR. The Microsoft MDAC setup will also automatically run again, but the previous installation (of the Experimenter Setup Utility) will have taken care of installing or updating any data access components or dll files. Exit the setup program when it has completed.

Making the Software Web Accessible

Files need to be placed in a web directory where clients (experimenters and subjects) can access them. As the fileserver is running IIS, it will have a directory called INETPUB. Its location is probably C:\INETPUB, but might be somewhere else depending on how the IIS is configured. In particular, a WinNT fileserver may have the INETPUB directory on the D: partition. IT personnel may need to be consulted regarding this information.

In the INETPUB directory is a subdirectory called WWWROOT. Create a subdirectory the INETPUB\WWWROOT directory to hold the software's asp and html files. A recommended subdirectory name is ONR, but the user can specify any name desired. Once INETPUB\WWWROOT\ONR has been created, copy all the files from the

(path)\ONR directory (where files were "FTPd") to the new INETPUB\WWWROOT\ONR directory. NOTE: The user should ensure that the ONR.mdb file is not READ ONLY. Experimenters and subjects will be writing data to this file, so it must be set to READ/WRITE.

Next, create a subdirectory named ART under INETPUB\WWWROOT\ONR. Once INETPUB\WWWROOT\ONR\ART has been created, copy the two files from the (path)\ONR\ART directory (where files were "FTPd") into the newly created INETPUB\WWWROOT\ONR\ART directory.

To enable web sharing on the INETPUB\WWVv1ROOT\ONR directory, use WinNT Explorer. Once web sharing has been enabled on this directory, the Experimenter Setup Utility and the Subject Decision Interface are available for access and use. Then when enabling web sharing, the use of an alias can shorten the URL name. For example, assume that the fileserver name is SERVERl, and that alias ONR has been set for the INETPUB\WWWROOT\ONR directory. The Experimenter Setup Utility could then be accessed at http://SERVER1/ONR/ONRExp.asp, and the Subject Decision Interface could then be accessed at http://SERVER1/ONR/ONRPlay.asp. Of course, an IP address could be used in place of the fileserver name SERVERl.

Reinstallation or Upgrade Installation

If the software needs reinstallation (for example, if an upgrade becomes available), the same procedure is followed as in the original installation. There is one important difference, however. Two dll files will need to be unregistered prior to the reinstallation, and then reregistered after the reinstallation. Proceed as follows,

Step 1. Reboot the server. This breaks any connection between ISS and the two dll files mentioned below.

Step 2. Unregister the following two dll files. Use the Windows START menu and choose the RUN option to execute:

regsvr32.exe/u "C:\ProgramFiles\ONR\ONR.dll"
and regsvr32.exe/u "C:\ProgramFiles\ONR\ONRGamePlay.dll

Of course, these commands should be modified for the directory indicated in the original installation (see above).

Step 3. The new ONRAII and ONRGamePlay.dll files will be included in the directory where the upgrade is FTPd. Copy them into the C:\ProgramFiles\ONR directory (or which ever directory is appropriate).

Step 4. Reregister the dll files by using Windows START/RUN menu to execute:

regsvr32.exe "C:\ProgramFiles\ONR\ONR.dll"
and regsvr32.exe "C:\ProgramFiles\ONR\ONRGamePlay.dll

Of course, these commands should be modified for the directory indicated in the original installation (see above).

Once the dlls have been taken care of, the upgraded web application files can be copied into the directory where the html, asp, etc. files were copied during the original installation.

Data Storage and Retrieval

Parameters and information from the Experimenter Setup Utility, and data recorded via the Subject Decision Interface are stored in a SQL database named ONRExp.mdb. It may be exported to Microsoft Access or Microsoft Excel for analysis directly or imported into a statistical package. All subject actions are recorded and time stamped. That is, the database contains the subjects' final choice of cells as well as cells selected and deselected (if this option is in effect), and the time at which each cell was selected or deselected. Additionally, subject payoffs, decisions regarding the fixed payment option, etc. are also included. These data will be used to identify search strategies, the payoffs to these strategies, and the factors that affect the choice of strategy.

Distribution List

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